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ABSTRACT

Ohio's Model Competency-Based Science Program is designed to provide direction for school districts in developing local competency-based science education programs. This guidebook provides direction for those responsible for developing district science programs. Section 1 is an introduction to competency-based education that covers the spirit and intent of the Model, and components of a local science program. Section 2 concerns the philosophy and goals of the Model. Section 3 focuses on developing a school science program and covers developing a scope and sequence framework, applying topics and units to the framework, developing grade-level instructional objectives, and developing performance objectives. Section 4 examines science instructional and performance objectives in grades pre-K through 12, and contains sample instructional objectives by strand and sample performance objectives. Section 5 looks at assessment and intervention services. The appendices cover learning episodes, science materials and equipment, health and safety issues, science education resources, and sample learning skills indexes. Contains a glossary and a 73-item bibliography. (LZ)

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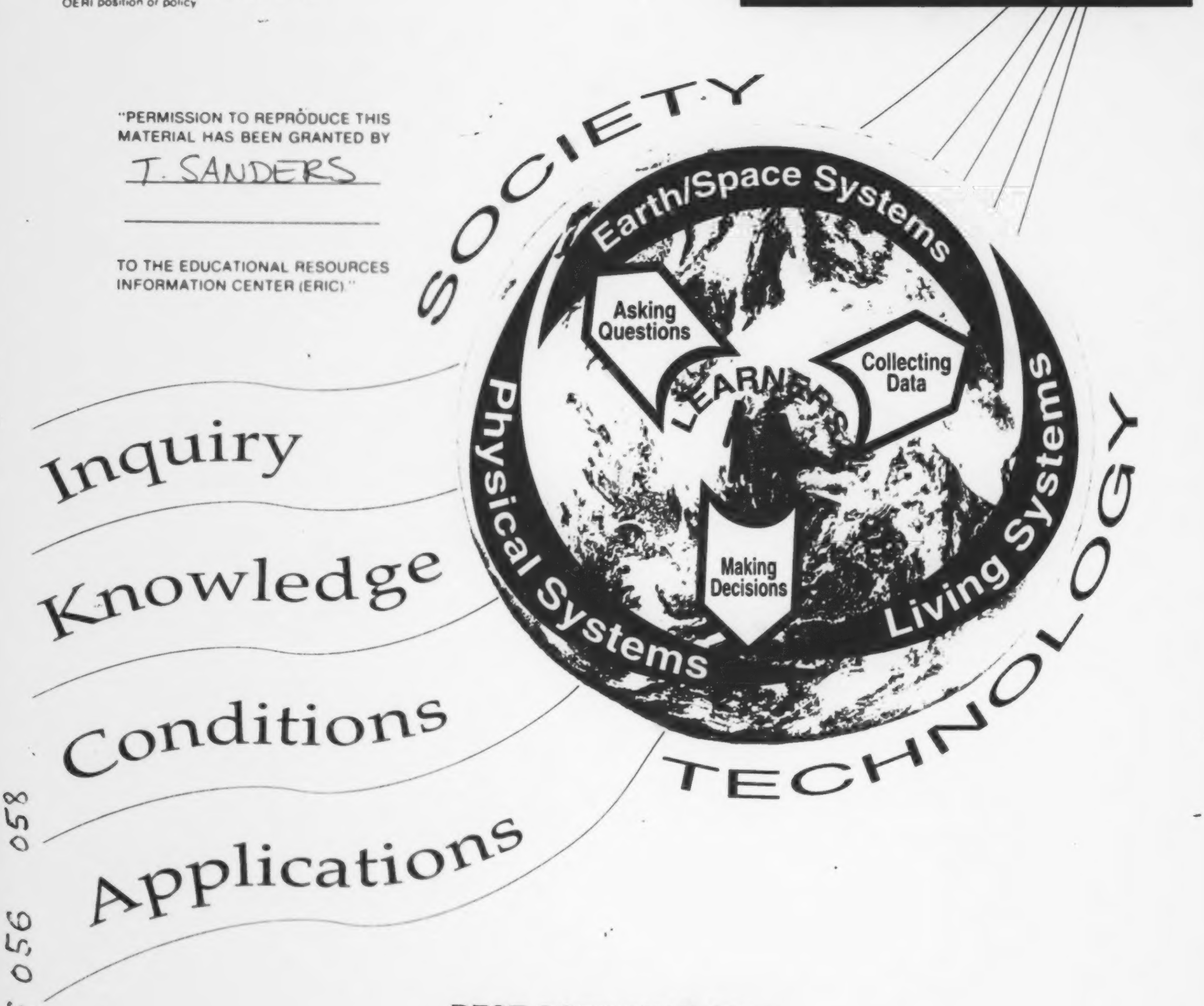
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SCIENCE MODEL TOOLS DEVELOPMENT

In order to assist districts to develop their competency-based science programs several Macintosh* computer-based Science Model Tools have been developed. The HyperCard 2.1* based Tools can be used to access the Science Model for interacting and adapting text, and recording committee work. The Tools were created by the science team of the Ohio Department of Education, Division of Curriculum, Instruction, and Professional Development. They are intended to complement technical assistance in support of local district science curriculum and program development efforts. Use of the Tools is a district option and does not infer any additional requirements for competency-based education.

Together the Tools provide or support

- Orientation to the Model and a base for professional development;
- Full text access to the Model;
- District science curriculum development; and
- Open-ended science program development.

Science Model Tools

Planning suggestions and strategies to guide local science committee work on district science programs are identified in the Science Model. The Science Model Tools aids using these suggestions and strategies by district science curriculum committees. They can be used independently and are designed to functionally complement each other. Below is a thumbnail sketch of each of the three Tools — Overview, Text, and Instructional Strands.

Overview Tool. This Tool highlights supporting text from the Science Model; provides a medium for completing self-paced or presentation-based orientations; and speeds visual navigation through the spirit and intent of the Model.

The Overview Tool can stand alone as an "executive brief on a disk."

Text Tool. This Tool provides flexible computer-based access to the printed text from the Science Model; accesses Science Model chapters by Table of Contents and selected text by key words; and prints and exports chapter text for hands-on or computer-based cut and paste editing.

The Text Tool can stand alone as a "Science Model on a disk."

Instructional Strands Tool. This Tool serves as an open-ended work tool for district science curriculum and program development; speeds navigating and selecting Model Instructional and Performance Objectives; facilitates science curriculum committee work to blend ideas from all four instructional strands into district-level instructional and performance objectives with computer-based cut and paste capabilities; records and coordinates local grade-level instructional and performance objectives with instructional and assessment resources; and prints and exports all district level materials created with the Tool.

The Instructional Strands Tool can build a "science curriculum and program on a disk."

If the use of these tools would benefit your committee, for information on how to obtain the Science Model Tools please contact

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FOREWORD

In 1983, the State Board of Education responded to the public's increasing expectations for learning by requiring competency-based education (CBE) in English composition, mathematics, and reading. As a result, the conditions necessary to promote a general education of high quality in all chartered schools have improved markedly. Such improvement is only possible when state leadership provides the flexibility necessary for local schools to establish educational programs that are responsive to local needs. Education in Ohio benefits immeasurably as a result of this understanding.

The need for the educational community to be able to document, in language easily understood by the general public, the status of educational progress is vital. In response to this need, the 118th General Assembly enacted Sections 3301.0715 and 3301.0716 of the Revised Code, which require the board of education of each city, exempted village, and county school district to implement a competency-based education program for language arts and mathematics. Subsequently, the 119th General Assembly enacted Section 3301.0720 of the Revised Code which in Section 1 required the State Board of Education to recommend for schools a model science curriculum including supporting recommendations relative to this curriculum: 1) lists of minimum supplies and equipment, with special emphasis on safety equipment; 2) acquisition and replacement schedules for supplies and equipment; and 3) safety procedures. In March 1992, the State Board of Education resolved its intent to extend competency-based education to science and social studies, and directed the Ohio Department of Education to prepare model programs in each discipline.

It is the responsibility of city, exempted village, and county school districts to develop and implement competency-based education programs. **Five criteria are required for CBE programs in Ohio:**

1. Performance objectives for composition, mathematics, reading, science and social studies;
2. Instructional objectives designed to ensure that the specified performance objectives can be attained;
3. Provisions for periodic assessment (including annual district-wide assessments in grades one through eight) of learner performance to measure progress toward achieving the specified performance objectives;
4. A program of intervention services for those who require support and enrichment; and
5. Written policies and procedures regarding the participation or exemption of handicapped learners.

Additionally, in response to Section 1 of Section 3301.0720 of the Revised Code, it is the responsibility of school districts to develop, implement, and provide upon request:

1. Lists of minimum supplies and equipment to support the science curriculum;
2. Acquisition and replacement schedules for supplies and equipment; and
3. A risk reduction and safety program.

The quality of locally developed curricula has been continually improving. These efforts are acknowledged and commended. We cannot, however, be satisfied with past and current successes. The need to design and implement a curriculum that reflects important and dramatic changes in our society is clear and requires that we be responsive to the educational implications of those changes. These model programs have been designed to improve student achievement, improve the quality of curriculum and strengthen school and community relationships through better communication. Appreciation is extended to those educators and Ohio citizens who contributed to the development of these competency-based education programs by sharing their time, expertise, and materials.

"Students will not have adequate opportunity to learn science if their teachers lack essential resources. There must be opportunities for teachers and other school staff to learn through sustained and comprehensive professional development. The school science program is very demanding of school staff. Without professional development, these demands cannot be met. A range of resources must be available to teachers and students, from science equipment to adequate individual attention to the needs of each student. It is the responsibility of all levels of the educational system to be inventive in uncovering useful resources. They must seek opportunities to recognize students, parents, volunteers, and teachers as useful resources."

— Statewide Science Advisory Committee, December 7, 1993.

INTRODUCTION TO COMPETENCY-BASED EDUCATION

Ohio's Model Competency-Based Science Program is designed to provide direction for school districts in developing local competency-based science education programs. This Model is designed to be used to guide the development of district curriculum. Teachers' instructional guides are developed from local curriculum and appropriate instructional resources. **This Model is not intended to be used directly by teachers as an instructional guide**. A great deal of flexibility is afforded to school districts in terms of formatting, grade-clustering, specification of conditions and criteria for performance, and other specifications. These areas should reflect the policies, procedures, and philosophical perspectives of district educators and policy-makers.

The ultimate purpose of *Ohio's Model Competency-Based Science Program* is to move Ohio towards the national goal – "first in the world in science ... achievement by the year 2000." In order to achieve this purpose, developers of local science curricula will use this Model as the basis of a locally developed/adapted competency-based science program. Teachers will then translate the instructional and performance objectives from their local science curriculum into science learning experiences ensuring that learners are appropriately challenged and demonstrate achievement to the limits of their abilities. Teachers will assess learner success in terms of both processes and products which focus upon clusters of skills, complex performances, analysis and communication strategies, and demonstrations of increasingly sophisticated science literacy that emerge over time. The sample grade-level performance objectives that follow the sample grade-level instructional objectives are designed to inform without restricting instructional practice and are especially important.

Teachers and administrators alike should become familiar with the philosophy, goals, and objectives found in this Model. The local district team responsible for curriculum development and competency-based education must be able to view the entire program holistically, yet work to facilitate implementation of the component parts. The introductory sections which follow immediately are designed to provide direction for those responsible for developing the science program.

The science model, pre-K through grade 12, includes the following:

1. Suggested instructional objectives;
2. Suggested performance objectives;
3. Recommended strategies for assessment;
4. A recommended program of intervention services (enrichment, reinforcement, and support).
5. A list of recommended types of supplies and equipment, with special emphasis on safety equipment;
6. Recommended strategies for formulating an acquisition and replacement schedule for supplies and equipment; and
7. Recommended strategies for formulating a risk reduction and safety program.

Ohio's Model Competency-Based Science Program, including all prescribed elements, has been approved by the State Board of Education subsequent to consultation with a broadly representative advisory committee and many other organizations and individuals. The Model reflects years of learning theory, practice, and research. The major objective of competency-based education programs is to guarantee consistency among the written, implemented, and assessed curricula in Ohio schools. It cannot be assumed, however, that the translation from the written curriculum to the taught curriculum and the attained curriculum can be accomplished without a focused effort. That effort must begin with the development and implementation of local science curricula and accompanying instructional programs (see Developing a School Science Program). The local science curriculum should be comprehensive in scope, and sequenced so as to provide developmentally appropriate instruction throughout the pre K-12 program.

In order to help school districts develop all the elements of a comprehensive, competency-based education program, the State Board of Education has established *Ohio's Model Competency-Based Science Program.*

Spirit and Intent of the Model

Ohio's Model Competency-Based Science Program provides leadership for the local establishment of standards for optimal science experiences for learners in Ohio schools. It does not predispose local or state accountability standards. It is designed to provide guidance for the development of district science programs and other CBE requirements, the selection of instructional materials, equipment and safety procedures, inservice and preservice professional development programs, the Ohio Proficiency Testing Program, and other diagnostic and accountability programs.

The following principles form the basis of this *Ohio's Model Competency-Based Science Program:*

Science is for ALL students. A basic level of scientific literacy is needed for an informed citizenry. This is also fundamental to the rigorous study of science for those interested in pursuing careers in science and applications of technology. The emphasis is to attend to students' individual learning strategies and styles, including those of underrepresented and underserved groups.

Science content is effectively learned by **actively engaging** in investigations of the world. At every grade level science content is learned more deeply through a process approach. Science instruction is successful when students begin to ask their own questions and conduct their own investigations. Topics for study should be relevant to students' lives.

The science program offered in schools must be **articulated, pre K-12** to meet the goals set by districts' science curricula. The Model does not mandate a scope and sequence (i.e. units of study at grade levels). Districts will be responsible for developing a scope and sequence and for selecting the specific content that will lead to the eventual understandings of the big ideas of science. The organizing concepts that are stated in the Thematic Ideas goal of the Model represent a compilation of the big ideas of science as defined by Project 2061.

When choosing and organizing the scientific content for a science curriculum, the content should be *grounded in* and *connect* the three domains of science identified by the National Committee for Science Education Standards and Assessment — **science in physical, living, and earth/space systems**. These should be connected across a school science curriculum, pre K-12.

For school science to be relevant to the student's world and to actively engage the student's thinking, instructional and performance objectives should be constructed to reflect all four instructional strands of the Model. The four instructional strands are: **Scientific Inquiry, Scientific Knowledge, Conditions for Learning Science, and Applications for Science Learning.**

Instructional and performance objectives should emphasize **higher order thinking skills and complex performances.**

In summary:

1. Science is for All Students.
2. Science content must actively engage learners.
3. Science programs should be articulated, pre K–12.
4. Science content should be grounded in and connect the three domains of science — science in physical, living, and earth/space systems.
5. Science programs must adequately reflect all four instructional strands of the Model — Scientific Inquiry, Scientific Knowledge, Conditions for Learning Science, and Applications for Science Learning.
6. Science instructional and performance objectives should emphasize higher order thinking skills and complex performances.

Components of a Local Science Program

The district science program should demonstrate an articulation of rigorous science instruction across the pre K-12 continuum . Specifically, the development of a science program involves constructing a scope and sequence framework which organizes units of study using organizing concepts of science, the development and selection of topics and units of study derived from the three domains of science (science in physical living and earth/space systems), and the development of instructional and performance objectives. The development of a school science curriculum also includes consideration for the alignment of instructional methods and assessments.

OBJECTIVES. Sample grade-level performance objectives for science have been generated from the sample grade-level instructional objectives that appear on these same pages. These objectives are representative of the optimal performances indicative of the essential knowledge and skills to be expected of learners. Even the most clearly defined objectives, however, can provide only the structure necessary to achieve educational excellence. Instruction is the vital force in the process. The State Board of Education recognizes that instructional decision-making is best left in the hands of classroom teachers. Because the successful competency-based education program relies on the use of a variety of instructional methods, several examples of effective learning episodes (see Appendix A) have been provided.

ASSESSMENT. Central to the ideals of competency-based education (CBE) is the reliance on qualitative and quantitative data to make decisions. The decisions to be made in a CBE program occur at many levels from state-mandated requirements of CBE through assessments that are used to make instructional decisions at the individual and classroom levels. Reporting the results of assessments to various people and agencies in a clear and meaningful manner is an integral part of the assessment process.

Section 3301 of Revised Code requires that annual district-wide, assessments in grades one through eight be administered in a standardized fashion. Standardized fashion refers only to the administration of the assessment. This means that all students in the district must be assessed in the same manner, using common scoring criteria, in an appropriate time frame. Assessment results – the percentage of students not making satisfactory progress on district performance objectives in grades one through eight and final course grades in grades nine through twelve – must be reported to the state through the Educational Management Information System (EMIS).

The essential differences between accountability and instructional assessments lie in the level of standardization of the assessment tools being used and the reporting of results. Depending on the level considered, the practices and reporting of the assessments must be clear and meaningful to the intended user of the assessment information. In any case, an array of assessments should be used to gather valid and reliable information to make decisions regardless of the level of standardization. **Many types of assessment tools exist and are available from a variety of sources. Types used may include interviews, observations, student self assessments, projects, presentations, performances over various time frames, a variety of portfolio**

methods, standardized norm-referenced tests, standardized criterion-referenced tests, and many others. The vital concept is that decision making should be based on information gathered using different sampling techniques. The common unifying measure for assessments is provided by the performance objectives designed by the district and integrated into its science curriculum.

Good instruction is the best preparation for assessment. Assessments designed to support instruction may be characterized as informal, adapted to local context, locally scored, sensitive to short-term change in students' performance, and meaningful to students. Assessment tasks should be designed to closely resemble real learning tasks. Assessment tasks will provide students, teachers, and parents immediate, detailed, and complex feedback.

Indicators of competence should be used as the basis for making decisions about individual student achievement on prescribed performance objectives. Such indicators should consider:

> **Coherence of Knowledge.** Assessment should tap the connectedness of concepts and the student's ability to access interrelated chunks of information. Student understanding should be demonstrably integrated and structured.
>
> **Principled Problem Solving.** Assessment should focus upon the underlying principles and patterns needed to solve problems rather than the surface features of a task.
>
> **Knowledge Use.** Accessing knowledge and appropriately applying scientific concepts is important. Assessment should determine students' capacity to do this.
>
> **Automatized Skills.** Assessment should determine the degree to which students competently use basic skills in performances.
>
> **Metacognitive or Self-Regulatory Skills.** Assessment should determine whether students are able to monitor their own understanding, use strategies to make questions comprehensible, evaluate the relevance of accessible knowledge, and verify their own solutions.

INTERVENTION SERVICES. Recognizing that alternative or supplemental action designed to enrich, reinforce, and support student learning relative to the specified performance objectives will sometimes be necessary, suggested intervention services have been identified for science (see Assessment and Intervention Services). The teacher must be able to identify the need for intervention, design the instructional form it will take, and implement the action. Teachers must have the capacity to use content material for these activities, instruct for specific learning styles, and appropriately regroup students as special needs arise. The ability to understand and use various diagnostic instruments, analyze assessment data, and teach prescriptively is a critical element of effective intervention.

CBE REPORTING REQUIREMENTS. All CBE programs are required to collect and report information about student performance. School districts are required annually by July 31 to collect, compile, and make available to the State Board of Education, **upon request,** all of the following:

1. Copies of the assessment instruments, by grade level, used during the preceding school year to determine student progress toward achieving the specified performance objectives, including information about the dates and methods of administration of the instruments and the methods of scoring or standards used for evaluating the results to determine whether or not students have made satisfactory progress toward achieving the objectives;
2. Data on the number and percentage of students, by grade level (one through eight) and by school building, who were shown by the assessment instruments not to have made satisfactory progress toward achieving the objectives during the preceding school year;
3. Information about the types, and a description of each type, of intervention services available to students who were shown by the assessment instruments not to have made satisfactory progress toward achieving the specified objectives;

4. The number of students who received each type of intervention service during the preceding school year by grade level and school building;
5. Estimates of the cost of providing intervention services to those students who were shown by the assessment instruments not to have made satisfactory progress toward achieving the objectives and who are not receiving intervention services, and the basis on which such costs were estimated; and
6. Additionally, school districts must provide for making this information, excluding copies of assessment instruments, available for inspection by the public at the district board's offices. Copies of the information must be provided to any person upon request. A reasonable fee may be charged for the cost of reproducing the information.

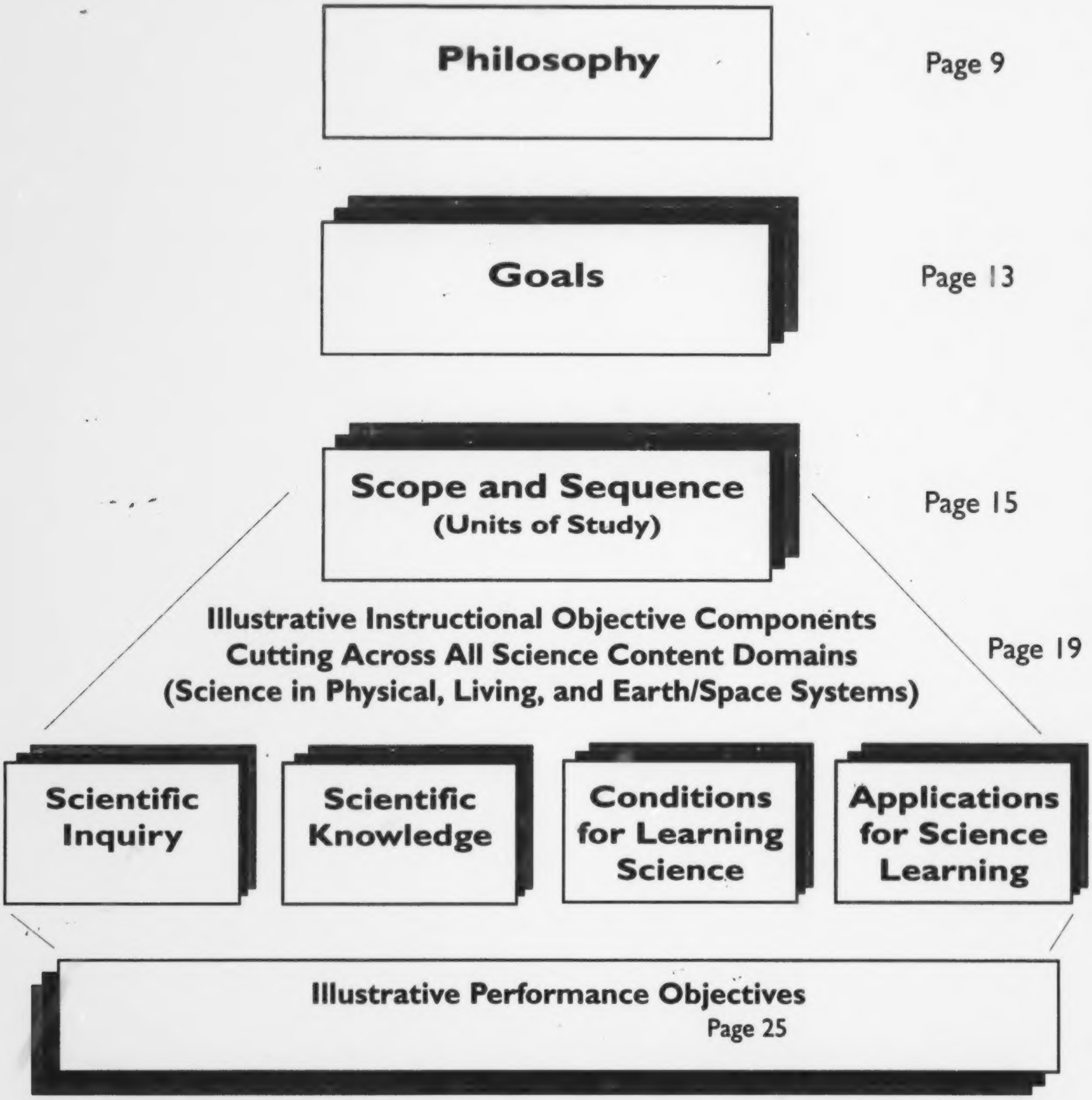
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FIGURE 1. The diagram above is provided to communicate the structure and relationship of components of a local science curriculum based on *Ohio's Model Competency-Based Science Program*. It illustrates that the program begins with a Science Program Philosophy which is elaborated in the Science Program Goals. To achieve these goals, a scope and sequence framework of instructional units is designed. Units representing the three domains of science are organized on this framework and are enriched by blending components from the four instructional strands into instructional objectives. Finally, performance objectives are constructed from these instructional objectives.

PHILOSOPHY AND GOALS

The mission for education as stated by the State Board of Education is "to prepare all students of all ages to meet, to the best of their abilities, the academic, social, cultural, civic and employment needs of the twenty-first century, by creating learning communities that emphasize the lifelong skills and knowledge necessary to continue learning, communicate clearly, solve problems, use information and technology effectively, enjoy productive employment, appreciate aesthetics, and meet their obligations as citizens in a democracy."

Based on this mission, the State Board of Education supports local efforts to forge learning communities for elementary and secondary education based upon five fundamental guiding principles:

- All students can learn.
- Every learner possesses multiple intelligences.
- Participation in a learning community fosters growth.
- Diverse instructional strategies and environments increase learning.
- Learning is a lifelong endeavor.

Philosophy

LEARNING TO LEARN. Education should provide all students opportunities to develop the capacity to renew and extend their understandings throughout life. Present and future demands on this capacity continually arise from technological, cultural, and economic changes in society. Owing to the dynamic interrelation between and among science, technology, and society, some of these changes result from and lead to scientific advances in peoples' understanding of the natural world.

Through an array of experiences, including scientific explorations of the world, learners become conversant with a broad range of subject matter. Through these experiences, learners will become prepared to: 1) identify problems and sort out issues that can be addressed scientifically; 2) recognize and synthesize scientific knowledge and processes; 3) develop scientific skills pertinent to solving problems and resolving issues; and 4) solve problems and make informed, evidence-based decisions in a wide variety of contexts. In short, learners' ability to utilize information and other resources, perform effectively in their careers, and benefit from further education depends on the continuing development of scientific literacy over the entire course of a person's life.

Scientific literacy includes no less than:

- competence in scientific inquiry;
- a sense of wonder about the natural world;
- understandings of humans, other constituent parts of the universe, and their interactions and transformations;
- facility for synthesizing and applying the big ideas of science for the purpose of problem-solving and evidence-based decision-making; and
- a functioning perspective of the interrelations between and among the scientific endeavor, society, and technology.

Science for All Americans emphasizes the need for scientific literacy in the design of a science program by defining a scientifically literate person as: "...one who is aware that science and technology are [interrelated] human enterprises with strengths and limitations; understands key concepts and principles of science; is familiar with the natural world and recognizes both its diversity and unity; and uses scientific knowledge and scientific ways of thinking for individual and social purposes." (1990: ix)

Scientific literacy continuously develops when the science education program incorporates a wide variety of learning episodes which clearly emphasize:

- learning from concrete to abstract and from familiar to unfamiliar;
- learning from the local setting to the global setting;
- real world doing (hands-on, minds-on);
- cooperative and individual performance;
- learner self-evaluation and curriculum-embedded assessment;
- developmental appropriateness of process and content;
- cooperative planning by learners and leaders;
- interdisciplinary connections;
- assessing the risks and benefits while making choices;
- moving towards independence; and
- responsible decision-making in real-world contexts.

A science education program enriching enough to facilitate continuous development of scientific literacy will require powerful learning episodes that are relevant and engaging to all learners.

DEFINITION. School science should reflect the definition of science as established by the United States Constitution (as interpreted by the U.S. Supreme Court) and the National Academy of Sciences. According to the Federal Court:

> *the essential characteristics of science are:*
>
> 1. *It is guided by natural law;*
> 2. *It has to be explanatory by reference to natural law;*
> 3. *It is testable against the empirical world;*
> 4. *Its conclusions are tentative, i.e., are not necessarily the final word; and*
> 5. *It is falsifiable.*
>
> (McClean v. Arkansas, 1982; and Edwards v. Aguillard, 1987)

According to the National Academy of Sciences:

> *In science, everything we observe, measure, or discover must be successfully tested again and again before it is accepted as valid and as factual evidence of what is real. During the application of this scientific method, scientists review their data carefully–and with a healthy skepticism. Most important, the scientific method requires that fact-seekers remain open-minded, are willing to submit their theories to rational examination, and are willing to accept changes indicated by the signposts of evidence. It is easy to see how this approach encourages the acceptance of change, which in turn fosters thought, new ideas, and new hypotheses, all converging on a better understanding of nature.*
>
> (National Academy of Sciences, 1984)

SCIENCE AS AN ENDEAVOR. Science is one of many ways people explore and understand the natural world. Throughout human history, people from many cultures and educational backgrounds, working individually and collaboratively have participated in this endeavor in many different settings.

The ability of humans to explore and understand the natural world through science is predicated on the predictive power of science, embodied in the durability and reliability of its methods and powerfully elegant ideas.

These methods and ideas have enabled humanity to make significant discoveries and build a comprehensive understanding of themselves, other constituent parts of the universe, and their interactions and transformations.

Human explorations of the natural world have also enabled people to invent, adapt, and use technologies to enrich their lives, extend their life spans, and manage their lives under a wide diversity of ever-changing conditions. Human history has been punctuated by unprecedented advances in science and technology. A continuing assessment of the interrelationships among these advances, the needs of society, and the sustainability of our planet is an imperative that must be adequately addressed.

Making discoveries and building understandings of the natural world through the scientific endeavor rely upon making observations, drawing inferences, and exploring testable hypotheses. The target of scientific activity is, therefore, the development of operational understandings of how the world works. Some of these understandings are considered tentative while others exhibit durability in relation to observable evidence and confirmable predictions. This durability does not imply a causal relationship between the theories, hypotheses, and facts of science and the nature or working of the components of the universe, e.g., the theory of gravity does not cause, but it can supplement a description of a falling object. Rather, its utility can be found in its predictive and descriptive capabilities, e.g., the significance of the finite speed of light as a durable, measurable fact is the role it plays in comprehensive, powerful, yet tentative theories for predicting and exploring the characteristics of matter, energy, time, and space.

HOW STUDENTS LEARN SCIENCE. Students come to new learning situations with their own knowledge, learning styles, perspectives, and predispositions. These pre-existing conditions are then challenged, modified, and reconstructed based on new experiences. Ohio's Model Competency-Based Science Program is based on this philosophy and it will be the basis for the local development of an articulated comprehensive set of engaging and challenging science activities which will consistently and incrementally develop powerful scientific literacy. This science Model shares its philosophy of learning with major national curriculum projects including Project 2061, the Scope, Sequence and Coordination project, and the National Committee on Science Education Standards and Assessment.

SCIENCE AS A WAY OF KNOWING. The construction, renewal, affirmation and extension of operational understandings are the very essence of science as a way of knowing. Science should not be taught dogmatically, because dogmas are beliefs and ideas that cannot be tested and refuted. Though some of the knowledge generated by the scientific endeavor is difficult to test or refute, all scientific knowledge can nevertheless be tested and, if the weight of repeatedly observed evidence is overwhelmingly contrary, refuted.

Advances in the scientific view of the world are dependent on the durability of scientific ideas and theories, and the expansion of their reliability. According to the *California Science Framework* (1990), "Scientific theories are constantly subject to testing, modification, and refutation as new evidence and new ideas emerge. Because scientific theories have predictive capabilities, they essentially guide further investigations."

All student questions in science class should be treated scientifically and with respect by other learners and leaders. Questions that cannot be investigated scientifically should be directed to authorities familiar with the contexts of these questions (e.g. philosophers, family members, guardians, and clergy).

OPPORTUNITY TO LEARN. Science learning can only occur when teachers have enabling resources — adequate materials, continuous professional development, and time to implement the teaching of science as described in this Model. Learning communities do not develop without effort. For teachers to facilitate students' learning, they must serve as role models. This means that teachers need to be confident using science processes and content so they are able to provide activities and experiences that promote student interest. To reach this stage of professional development, teachers must be provided with opportunities to update their knowledge of science and instructional methods and techniques. Technology is playing an ever-increasing role in daily life. Its influence should be reflected in schools. Teachers need time to plan as individuals, as members of instructional teams and as a member of a pre K-12 science staff. Time to plan, time to learn, and materials and facilities to support science instruction emphasize the need for adequate resources.

Finally, there must be a commitment to equity. Disparities between districts, schools, and classrooms that affect students' opportunities to learn must be minimized. The elimination of inequities is a critical goal of a competency-based science program in Ohio schools.

Goals

The following Goals are supported by grade-level objectives organized in four instructional strands. School science programs developed with this model will support and enhance the overall school program. These Goals represent the culmination of science experiences and should be used as a filter for the consistency and development of an articulated science program. They do not prescribe specific content, instructional topics or themes, skills, or processes and should not be used as an organizing scheme.

GOAL 1: THE NATURE OF SCIENCE. To enable students to understand and engage in scientific inquiry; to develop positive attitudes toward the scientific enterprise; and to make decisions that are evidence-based and reflect a thorough understanding of the interrelationships among science, technology, and society.

As a result of a successful science education, the learner will:

demonstrate curiosity, open-mindedness, skepticism, and ethical behavior while participating in scientific inquiry;

develop and use scientific skills and concepts to explore how the natural world works and to examine and propose solutions for its problems;

formulate questions, hypotheses, and models drawing upon appropriate means, including logic and imagination, and design investigations to test them;

choose and use appropriate means for making observations, gathering evidence, presenting the evidence in appropriate formats, performing analyses, drawing inferences, and formulating conclusions; and use them to initiate additional investigations and applications;

recognize that scientific knowledge is always open to refinement and can never be declared absolutely certain as demonstrated by the capacity and willingness to modify personal insights and understandings in light of additional evidence; and

engage in personal and group decision-making, using risk-benefit analysis, about the use of technology to solve problems of human adaption.

GOAL 2: THE PHYSICAL SETTING. To enable students to describe the relationship between the physical universe and the living environment, and to reflect upon and be able to apply the principles on which the physical universe seems to run.

As a result of a successful science education, the learner will:

investigate and distinguish among the various macro and micro components, of the universe; explain how they relate to one another; and elaborate on how humans have arrived at their understandings of the universe;

explore and explain the fundamental principles governing relationships between and among matter, energy, space, and time;

construct and interpret conceptual, physical, and mathematical models to explain the motions of the earth and the materials and systems that compose it; and

make and act upon evidence-based decisions to ensure a sustainable environment.

GOAL 3: THE LIVING ENVIRONMENT. To enable students to describe the relationship between the structure and functions of organisms, to assess how organisms interact with one another and the physical setting, and to make decisions that ensure a sustainable environment.

As a result of a successful science education, the learner will:

recognize and explain the similarities and differences among organisms in terms of structure, function, and behavior;

investigate and interpret the causes of diversity and similarity among existent and extinct organisms through time;

construct and interpret conceptual, physical, and mathematical models to explain how humans and other species are linked directly or indirectly with each other and in ecosystems;

investigate and explain how the interactions of psychological, biological, physiological, social, and cultural systems affect mental and physical well-being; and

evaluate how societal decisions about science and technology may impact the survival of various species.

GOAL 4: SOCIETAL PERSPECTIVES. To enable students to analyze the interactions of science, technology and society, in the past, present and future.

As a result of a successful science education, the learner will:

recognize and respect that scientific inquiry and knowledge represent the accumulated work, over many centuries, of men and women in every part of the world;

identify and explain the significance of milestones that define the advancement of scientific inquiry and knowledge;

recognize and evaluate the impact of scientific inquiry and knowledge on human culture and how human culture impacts scientific inquiry and knowledge; and

contribute to the discourse relative to the scientific and technological priorities and their relationship to societal issues.

GOAL 5: THEMATIC IDEAS. To enable students to use major scientific ideas to explore phenomena, inform their decisions, resolve issues, and solve problems; and to explain how things work.

As a result of a successful science education, the learner will:

identify and explain systems, e.g. solar systems, ecosystems, organisms, and chemical and physical systems, by noting components and relationships;

use the concept of systems to organize seemingly isolated facts and observations into comprehendible explanations of how things work;

use conceptual, physical, and mathematical models as simplified representations to help explain and explore how things work or might work;

distinguish among and use the simplifying principles and aspects of systems, e.g. stability, equilibrium, conservation, and symmetry, that remain predictably constant to explore phenomena and make decisions;

distinguish among and apply patterns of change, including trends, cycles, evolution, and chaos, to explore phenomena and make decisions; and

recognize and explain the implications of phenomena understood at various levels of complexity and scale.

DEVELOPING A SCHOOL SCIENCE PROGRAM

The purpose of a school science program, as stated in the philosophy of this Model, is to prepare all students to be successful in today's and tomorrow's world. In order to reach this goal, learning communities must adopt policies, priorities, and practices that will establish optimal learning conditions. In Ohio, the authority for these policies, priorities, and practices reside at the school district level. This is appropriate since Ohio has widely diverse communities. The main purpose of this document, therefore, is to provide guidance for school districts to develop school science programs.

Constructing a Scope and Sequence Framework

The power of this process is that it provides common organizers to allow for the construction of a seamless, articulated science curriculum for all grades. It permits the construction of a local science program that is free of redundancy, gaps, and inconsistencies. This model suggests five organizing concepts of the important transdisciplinary ideas of science similar to those found in Project 2061 (see Goal 5, Thematic Ideas). Other references may use more or fewer organizing concepts. Organizing concepts are complex scientific ideas that connect the domains of science and can and should be reinforced at all ages across all science instruction. A science curriculum in Ohio should demonstrate how students are to develop an understanding of organizing concepts such systems, models, constancy, patterns of change, and scale and complexity whether organized as integrated courses or as domain-specific courses. **Using this process provides freedom for local curriculum committees to select instructional units while assuring articulation across grades toward meeting local district goals.**

Applying Topics and Units to the Framework

Generally speaking, one of the more difficult tasks is to decide on the placement of content (Scientific Knowledge) across the framework. Teachers of all grade levels should meet together and decide on the appropriate placement of science units containing scientific knowledge and skills that are increasingly sophisticated. In general, instruction should emphasize relevance and appropriateness for the grade level selected and should cover the three domains of science across each grade range - primary, intermediate, middle and high school. School districts should emphasize the rigor of the science learning in each unit, not coverage of textbooks. The essence of the approach promoted in this Model – and many national curriculum projects including Project 2061 – is that a few units experienced in depth over time, using a variety of methodologies is the preferred strategy for optimal science learning as illustrated in the goals of this Model. The spread of scientific knowledge and skills may occur by offering coordinated, integrated units and courses (every science, every year) or discrete courses across a span of years. The instructional and performance objectives presented in this model illustrate the level of sophistication of science knowledge and skills at succeeding grade levels. This Model does not place specific instructional units at specific grade levels. Several suggested instructional sequences follow the instructional and performance objectives.

Developing Grade-Level Instructional Objectives

In this science Model, the sample instructional objectives are arranged in four instructional strands. These strands represent the essential components of quality instructional and performance objectives and are based on the emerging National Standards. The four instructional strands highlighted in this Model are:

- Scientific Inquiry– the desired technical skills and abilities;
- Scientific Knowledge– the big ideas of science to be studied;
- Conditions for Learning Science– the strategies and activities for learning; and
- Applications for Science Learning– ideas for how learners may use their learning.

Writing instructional objectives for local science curricula is a process of blending ideas from the four instructional strands at the local level. This allows a high degree of flexibility for local science programs. These resultant instructional objectives identify the essential learning that should occur at a given grade level.

EXAMPLE. The following illustrates how an instructional objective written for a ninth grade science course could be assembled. Assuming that the local curriculum committee has determined that an instructional unit on the "Physics of Motion" will be taught at grade nine, the following objectives were selected from the Ohio Science Model with a knowledge of available instructional materials, considering the teacher's expertise, and considering the school setting:

Scientific Inquiry
The learner will translate information from, and represent information in, various forms. (Gr. 9)

Scientific Knowledge
The learner will investigate the principles that describe and predict the motions of objects. (Gr. 8)

Conditions for Learning Science
The learner will be fulfilling responsibilities as part of a research group. (Gr. 9)

Applications for Science Learning
The learner will be predicting and investigating the working of toys and tools while controlling and manipulating variables. (Gr. 10)

From these component instructional objectives, the following instructional objective could be written:

> Learners will work in a variety of groupings to investigate the principles of motion that govern how various toys move. They will present several drawings and graphs which represent these motions.

Instructional objectives should be tailored to match the units of study determined for each grade level. Objectives presented in teacher's guides to instructional materials can be of assistance in this process. Although the objectives in this Model are written to allow knowledge from the three domains of science to be taught in each year, the integration of science – science experiences that are connected across several domains and relevant in students' lives – can be achieved in a variety of separate, domain-specific courses if one domain of science is the primary focus of the science offering. What is critical is that the connections between the three domains of science are necessary for comprehensive understanding. If grade levels are organized around discrete courses, as is often the case, the scientific knowledge chosen for the instructional objectives specified for that course should directly match the course, instructional materials, student needs, and teacher preparation for the course. It should be emphasized that the nature of instruction is generally conceptual below grade 9 and more quantitative and abstract in grades 9-12.

Once grade level instructional objectives are created, a set of criteria by which a teacher or another evaluator may assess student achievement must be established. These statements are the performance objectives.

Developing Performance Objectives

A performance objective is designed to provide a benchmark of students' achievement along their progression toward meeting science program goals. Performance objectives must be written for all levels in the science curriculum course of study. They help to determine the learning activities that will be conducted at each level. Additionally, they also guide the development of classroom-based and district-wide science assessment. **Performance objectives are statements of what students know and can do as a result of the science instruction at that level.**

Performance objectives may be written in several different ways. They all, however, contain a specific description of how students can demonstrate what they know and can do and how a teacher may apply a level of success to their demonstration. Generally, three levels of performance objectives can be written –acquiring, processing, and extending scientific knowledge. The grade-level performance objectives presented in this model are illustrative of a broad range of possible performance objectives. School science committees should use their grade-level instructional objectives and the examples of performance objectives in the model to create district performance objectives for the local science curriculum.

EXAMPLE. Using the instructional objective developed in the previous section, three possible examples of performance objectives are given below.

1. Acquiring Scientific Knowledge—
   Given a graph of the motion of a toy, the learner will verbally describe the motion of the toy with a high degree of accuracy.
2. Processing Scientific Knowledge —
   The learner will demonstrate an understanding of the concept of inertia by accurately contrasting the motion of two vehicles with differing masses.
3. Extending Scientific Knowledge —
   Using common classroom materials, the learner will construct a vehicle to efficiently move a heavy object and accurately explain how it works.

The objectives should not be discrete checklists of lower cognitive-level behaviors and should not be written exclusively in a behavioral format. Each should be specific enough to describe the level of performance expected at the appropriate level of sophistication for the learner and the criteria for assessing the quality of the performance. Using this assessment information, teachers and learners can then determine the level of achievement relative to the objective.

In every performance objective, district teams should attempt to ensure that the ideas represented by the four strands of the Model (scientific inquiry, scientific knowledge, conditions for learning science, and applications for science learning) are included.

The performance objectives in this Model were developed using this process. **The Model performance objectives are a small, illustrative set that should not delimit the scope of the district curriculum nor should they presuppose the number of performance objectives that a district may develop.** Districts should assure that the performance objectives adequately represent the instructional objectives and that the skill of the teachers and students participating in the assessment of science learning has been considered.

SCIENCE INSTRUCTIONAL AND PERFORMANCE OBJECTIVES, PRE-K THROUGH GRADE TWELVE

The purpose of school science programs is to provide the conditions and experiences by which all students become scientifically literate. At its most basic level, scientific literacy is the capacity of a person to be able to ask questions, collect information, and make evidence-based decisions about scientific and technical issues in their own life. This development process begins with children when they are very young, accelerates during formal schooling, and then continues throughout life.

In the planning of quality science experiences, there are four major considerations. These considerations are embodied in this Model as instructional strands which follow in this section of the document. When instructional objectives for science are developed and as instructional materials are chosen, all four strands need to be carefully reflected.

The instructional objectives provided in this Model are presented individually in each of the four strands. In actuality, these represent the components from which quality district level instructional objectives are developed. When creating an instructional objective, district committees should select several ideas from across the four strands to create a rich instructional objective that is true to the spirit and intent of all four strands. This process is shown in the previous section entitled "Developing a School Science Program."

The instructional and performance objectives are provided as examples. Districts are free to use these objectives or to develop objectives of their own that are consistent with the spirit and intent of these Model objectives.

Instructional Objectives

The instructional objectives of this Model are organized in four instructional strands. The following sections explain the spirit of each strand.

STRAND 1: SCIENTIFIC INQUIRY. Model instructional objectives in the scientific inquiry strand illustrate the pre-K through grade 12 developmental usage of the cognitive, affective, and physical tools and safeguards for acquiring, analyzing, synthesizing, and communicating information and ideas relevant to the natural world. These model objectives complement the objectives found in the other three strands and elaborate on the goals for science education in Ohio.

As established by the emerging National Science Education Standards, the Scientific Inquiry strand explores the modes of inquiry, habits of mind, and attitudes and dispositions that we believe every learner should be empowered to employ and exhibit when engaged in science explorations and constructing their understanding of the natural world.

What science holds to be an increasingly comprehensive and reliable understanding of the living world and physical setting is supported by and subject to change by an ongoing process of observation of phenomena; collection, analysis and logical interpretation of information; and honest communication of ideas. Equally significant to a complete science program is direct, developmentally appropriate experience by learners in the formulation of questions for inquiry, design and performance of investigations, and participation in evidence-based decision making. Moreover, each of these systematic processes is augmented by a blend of pre- and co-requisite skills – critical thinking, computational, manipulative, observational, technological and others.

Some examples of questions learners should explore are:

> What is not known? What do we know? What do I need to do to find things out? What tools are at our disposal? Which tools will be most effective? Will new tools and processes need to be created for use in our investigations?

It is customary for scientists to extol openness to ideas since they are fully aware of the tentativeness of our understandings about the natural world. Scientists also exhibit institutionalized skepticism to ideas as an intellectual safeguard, while at the same time being cognizant of a measured certainty of the durability of these understandings. This dynamic balance is vital to the health of a discipline that is dependent on the predictive power of established principles and the need to appropriately refine or invent principles to account for the unexpected.

Essential among the customs and safeguards of the scientific endeavor is the ability to anticipate outcomes and events associated with investigations and to make accommodations for associated hazards and risks to ones self, others and the environment. Provisions for health and safety must be considered inherent components of investigative designs, measurements, and analyses.

By nature, scientific inquiry expands the domain of intellectual honesty beyond the sharing and reporting of all information pertinent to scientific investigations. It also requires shared responsibility from all members of the scientific community – producers and consumers – for recognizing, tracing, assessing and communicating the impact of uncertainty, error and bias on measurements, investigative designs and analyses. Just as the manner for doing science involves recognizing what influences our methods of inquiry, so do our own ideas and biases influence what we choose to investigate, filter the information collected during investigations, and mold the conclusion we draw from the results of our investigations.

Some examples of questions learners would explore are:

> How do we know? How and with what audience is this shared? What isn't being considered? What are the certainties and limitations? What is or can be reasonably inferred? What do I need to consider to find things out? What potential outcomes and precautions should I consider?

According to the emerging National Science Education Standards ethical inquiry refers to accuracy and precision in collecting, interpreting, analyzing, and reporting information; using data and technology in socially and culturally acceptable ways; openness to new scientific ideas; skepticism about scientific explanations; tolerance for ambiguity; and accommodation for health and safety.

Science should foster curiosity, creativity, and invention, and place as high a value on them as it does on knowing. Some examples of questions learners would explore are:

> How does it work? Does this conflict, support, extend what we already know? What and why do I need to know? Do I need to know more and what can I do to find things out? Was this useful? Was this interesting? What did I enjoy about this? What new questions, issues, problems do I want to explore?

This strand represents the manner with which we do science and must be used to guide how learners interact with the natural world in their schooling experience. Each objective is therefore an extension of what "The Learner will ..." be able to do. When blended with the objectives from the other three strands, the result is a rich experience that enables learners to construct a robust and powerful level of scientific literacy and to develop critical scientific and technical skills. Students' pre-K through grade 12 science experiences must facilitate immersion and development in every facet of the essence contained within scientific inquiry.

STRAND 2: SCIENTIFIC KNOWLEDGE. The instructional objectives in the Scientific Knowledge strand illustrate a variety of concepts, principles, laws, and theories. Ohio's science model does not mandate any specific organizing structure. Every local learning community should select or invent an organizing structure that is appropriate for science learning in the local situation informed by existing state and national standards, as appropriate. By addressing these objectives in concert with those found in the other three strands, a comprehensive science education program is possible.

Science for All Americans (1991) comments clearly on the disciplinary structure of scientific knowledge.

> *Organizationally, science can be thought of as the collection of all the different scientific fields, or content disciplines. From anthropology through zoology, there are dozens of such disciplines. They differ from one another in many ways, including history, phenomena studied, techniques and language used, and kinds of outcomes desired. With respect to purpose and philosophy, however, all are equally scientific and together make up the same scientific endeavor. The advantage of having disciplines is that they provide a conceptual structure for organizing research and research findings.* **The disadvantage is that their divisions do not necessarily match the way the world works, and they can make communication difficult** *[emphasis added]. In any case, scientific disciplines do not have fixed borders. Physics shades into chemistry, astronomy, and geology, as does chemistry into biology and psychology, and so on. (p. 10)*

The natural world has no artificial disciplines but is transdisciplinary and holistic. Therefore, learners will need to explore and confront the natural world as it presents itself and make sense of its complexity. What is needed now is an understanding of how scientific knowledge is developed and a systematic way to find and use the store of information needed for effective problem solving and decision making.

The development of scientific knowledge requires that students spend long periods of time experiencing powerful, relevant ideas. This strand identifies a limited number of important concepts, principles, laws, and theories understood as scientific knowledge. Each objective is an extension of the idea of what "The Learners will ..." know. The reader will notice that only three verbs (explore, pre K - grade 4; investigate, grades 5 - 9; and formulate, grades 10 - 12) have been used in this strand. The purpose of this is to indicate the level of sophistication of learners' developing understanding of scientific concepts. Verbs designed to guide activities should be selected from objectives in the other three strands. The skills (Scientific Inquiry), activities (Conditions for Learning Science), and uses of science (Applications for Science Learning) are to be chosen by teachers in combination with the scientific concepts in this strand to design relevant and engaging instructional and performance objectives.

Scientific knowledge does not stand alone in instruction. The objectives listed here, in concert with the objectives from the other three strands, will enable students to reach the goals and objectives previously identified. The instructional objectives in this strand were written so teachers, depending upon background and experience, will properly exercise their professional expertise to guide students in the construction of their own scientific knowledge.

Although these objectives specify fundamental understandings that all students should develop, they do not specify the full range of what students in a particular local setting should know and be able to do. Teachers and school systems must continue to construct science experiences that build on local needs, resources and environments, reflect the teachers' background and expertise, and stimulate the students to go far beyond fundamental understandings. The most important aspect of a school science program is that it must be relevant and engaging to students in their own integrated world.

STRAND 3: CONDITIONS FOR LEARNING SCIENCE. The Vision Statement for the State Board of Education begins with the belief that "All children will learn if the conditions for learning are right." It is the latter part of this statement that is the driving force behind this strand of *Ohio's Model Competency-Based Science Program*. This strand highlights and qualifies the kinds of science experiences students should have in Ohio classrooms, pre-K through grade 12.

The responsibility of educators is to provide the best possible conditions for learning and opportunities for every learner to participate. Science activities should be based on learners' cognitive level, strengths, and learning styles. Five major ideas run through this strand that have been identified in science education research and exemplary practice. These five major ideas have been drawn from the mathematics and language arts models, various school improvement models promoted by the Ohio Department of Education, and ideas, such as spaced-learning, from science education research. These are:

1. Students need to have **time** and to take time to construct their knowledge, i.e. time to think about, plan for, reflect upon, and participate in a multitude of quality science experiences.
2. Educators must plan and use **diverse instructional strategies and settings** in order to allow students many ways to think about and construct their knowledge.
3. Students must **communicate** their experiences and understandings in a variety of ways.
4. Multiple opportunities must be provided for students to **demonstrate their knowledge and skills**.
5. Science experiences must be **connected** to other subject matter and school experiences as well as their own lives, and school, community, and global issues and events.

These five ideas are woven through the instructional objectives at each grade level in this strand of the Model. The reader will notice that each statement in the strand begins with the stem "The Learner will be...". This implies that these statements are descriptive of the activity one should witness where science learning is occurring. The ideas are not discrete and are intentionally overlapping. In addition, there should be obvious overlap between the ideas expressed in this strand and the instructional objectives from the other three strands.

The following quote from Project 2061 emphasizes the importance of the conditions of learning science .

> *In learning science, students need time for exploring, for making observations, for taking wrong turns, for testing ideas, for doing things over again; time for building things, calibrating instruments, collecting things, constructing physical and mathematical models for testing ideas; time for learning whatever mathematics, technology, and science they may need to deal with the questions at hand; time for asking around, reading, and arguing; time for wrestling with unfamiliar and counterintuitive ideas and for coming to see the advantage in thinking in a different way.* ***Moreover, any topic in science, mathematics, or technology that is taught only by a single lesson or unit is unlikely to leave a trace by the end of schooling.*** *[emphasis added] To take hold and mature, concepts must not just be presented to students from time to time but must be offered to them in different contexts and at increasing levels of sophistication." (SFAA, 1993 p. 193).*

Once again, it is important that the instructional objectives in this strand be incorporated into the fabric of the science program and not used as the sole basis for an instructional activity.

STRAND 4: APPLICATIONS FOR SCIENCE LEARNING. A key component in the development of learners' scientific literacy is an increasing ability to use their store of scientific skills and knowledge when they are faced with new problems and issues. The development of this ability is incremental as learners participate in real-life situations across the school program. Effective science learning occurs when it is correlated to and integrated with the entire school experience. Once learners internalize this ability, it becomes useful for the rest of their lives. This fourth strand is designed to suggest age-appropriate, real-life experiences that will fully develop scientific knowledge and problem-solving skills while making school science **relevant** and **engaging** for learners. Using this strategy, learners will strengthen their scientific literacy and skills as they apply them.

According to the National Committee on Science Education Standards and Assessment (NCSESA), science content and skills must be ". . . applicable in many situations and contexts common to everyday experiences." (NCSESA, Feb. 1993)

The NCSESA states that science education should emphasize:

- *Incorporating scientific inquiry skills in personal, civic, and political decisions;*
- *Incorporating scientific facts, concepts, principles, and theories in personal, civic, and political decisions;*
- *Perspectives from the history of science and technology; and*
- *Recognizing that science and technology are influenced by culture and context in which they operate, and, in turn influence and affect that culture and context. (NCSESA, July, 1993).*

As is the case in the **Scientific Inquiry, Scientific Knowledge, and Conditions for Learning Science** strands, these model instructional objectives are arranged by grade level from pre-K to grade 12. Each instructional objective is an extension of how "The Learner will be..." applying their science knowledge and skills. These objectives only illustrate and suggest the application of science learning. Scientific inquiry skills, habits of mind, scientific knowledge, and the conditions in which these occur must be drawn from the other strands and combined with these objectives to frame the instructional picture.

Since *Ohio's Model Competency-Based Science Program* is considered to be seamless over the full span of thirteen or more years, teachers and other curriculum specialists need to be familiar with the instructional objectives at all grade levels. Particular attention needs to be paid to those objectives that appear one or two grades above and below the target grade level.

Performance Objectives

The performance objectives for science have been constructed by considering the instructional objectives from all four instructional strands — **Scientific Inquiry, Scientific Knowledge, Conditions for Learning Science, and Applications for Science Learning.** These objectives represent the optimal performances indicative of the essential knowledge and skills expected of learners. Even the most clearly defined objectives, however, can provide only the structure necessary to achieve educational excellence. Instruction is the vital force in the process. The State Board of Education recognizes that instructional decision-making is best left in the hands of classroom teachers.

The model performance objectives focus on both the processes and content of science. Assessments (written, performance, interview, portfolio and other styles) should focus on both processes and products of the science learning experience for students. Effective classroom assessment must examine genuine applications and evidences of students' science learning. Assessments of science learning should focus on complex behaviors performed by students in the course of classroom events and not on discrete science facts. The collection and analysis of information related to students' performances on complex tasks is authentic assessment. The assessment results are then used to modify and plan subsequent learning activities.

Sample Instructional Objectives by Strand

and

Sample Performance Objectives

Grade Level	Scientific Inquiry The learner will:	Scientific Knowledge The learner will:	Conditions for Learning Science The learner will be:	Applications for Science Learning The learner will be:
Pre-K	describe and group objects by similarities and differences. make predictions about what comes next in a sequence of objects and events. focus on and report observable changes. make sustained observations of changes. offer explanations for observed events and evidence of events. ask "What if..." questions and explore possible explanations. ask "Why..." questions about observed events. pursue their sense of wonder.	explore organisms and objects in terms of their attributes, actions, and changes. explore changes in himself/herself over periods of time. explore different conditions that affect the rate of change in the attributes of organisms and objects (e.g., melting of ice, changing leaves). explore observable patterns in their lives (e.g., seasons, day/night cycles). explore sensory-based descriptions of objects and organisms. explore phenomena of long and short duration. explore the relationship between models, dolls, and other toys and the real objects that they represent.	sharing ideas and impressions while observing events and manipulating materials. participating in the choice of topics to be explored. asking questions of peers and others about events and proposing explanations for them when they occur in the learning situation (e.g., falling objects, storms). caring for living organisms in the learning setting and at home (with adult assistance when necessary). manipulating physical objects to test ideas or models (e.g., blocks, beans, sand). repeating experiences several times to detect patterns in events. listening to, creating, and retelling stories about the natural world.	constructing puzzles, models, and other entities. assisting and observing adults in preparing food and common household tasks (e.g., snacks, meals, cleaning, gardening, washing dishes). observing and experiencing the durability of and care for objects and organisms (e.g., toys, pets, devices, common household objects). using resources efficiently.

Performance Objectives: Pre-Kindergarten

1. The learner will use his/her senses to collect information and describe objects.
2. The learner will observe and describe a familiar physical change (e.g., melting ice, breaking a stick) using terms such as before and after.
3. Given a set of familiar objects (e.g., buttons, shoes, leaves), the learner will sort the objects into groups and describe what is common in the groups.
4. The learner will observe a living organism and discuss what the organism needs to live.
5. The learner will listen to a story about a science concept and accurately report the story to another person.
6. The learner will ask "What if . . ." questions given a discrete physical circumstance (e.g., a stack of blocks, a ball and ramp).

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Grade Level

Kindergarten

Scientific Inquiry

The learner will:

- report observations systematically.
- measure liquids and granular materials using non-standard measures.
- compare observable characteristics of common objects (e.g., weight, size, color, texture, density).
- organize and explore how objects are measured or compared according to various scales (e.g., physical, musical and color palette).
- ask "Why?" and be able to accept "I don't know" as an acceptable response from others.
- take responsibility, under supervision, for the safety, health, and care of living organisms in the classroom and at home.
- gain independence, under supervision, in the care and appropriate and safe operation of commonly used devices and appliances in the classroom and at home.

Scientific Knowledge

The learner will:

- explore ways in which organisms and objects react to changing conditions around them (e.g., people wear coats in the cold, ponds freeze in the winter, balls move on ramps).

  explore moving objects and organisms.
- explore the recycling of objects in his/her environments.
- explore the direct impact of light, heat, sound and magnetism on various organisms and objects.
- explore observable patterns in their lives (e.g., seasons, day/night cycles, and geometric patterns in nature).
- explore qualitative descriptions of objects and organisms.
- explore a wide diversity of objects and organisms indoors and outdoors.
- explore the passage of time (e.g., morning, afternoon, today, tomorrow).
- explore the concepts of magnitude and distance (e.g., big/little, near/far, short/long).

Conditions for Learning Science

The learner will be:

- discussing explanations for ideas and events and asking clarifying questions individually and collaboratively.
- manipulating various containers to discover and compare capacities.
- safely and efficiently handling and using instruments.
- exploring extensions of the learning environment (e.g., laserdisc, audio recordings, museums, zoos, learning centers, nature centers, community resources, distance learning resources, scientists).
- following simple directions (e.g., recipes, scavenger hunts, rallys).
- using materials available in the learning environment to design ways to test explanations and ideas.
- repeating observations over extended periods of time, reflecting upon them, and talking about differences that have occurred between observations.
- contributing in a variety of ways to the work of groups.
- recording observations for self and others using a variety of technologies.

Applications for Science Learning

The learner will be:

- selecting, sorting, and caring for clothing, foods, and other common objects.
- measuring themselves and common objects using nonstandard units.
- describing events and telling stories.
- building structures and models from appropriately sized building materials (e.g., blocks, rods, wheels, balls, boards).
- caring for living organisms (e.g., pets, plants, livestock).
- using common devices and appliances (e.g., telephone, vacuum cleaner, television, radio).

Performance Objectives: Kindergarten

1. Given a set of pictures that tell a story, the learner will demonstrate understanding of observable patterns by explaining the meaning and sequence of the pictures.
2. The learner will demonstrate an awareness of changes over time by describing an event or process that he/she has observed.
3. When presented with a new situation, the learner will ask "What if . . ." and "Why . . ." questions related to his/her understanding of the scientific concept in the situation.
4. The learner will construct a recognizable simple model of a real object using familiar materials.
5. The learner will describe the subtle differences between routines that have occurred on different day (e.g., meals, traffic, play).
6. Given several similar items which vary in size, the learner will contrast the objects using the terms long/short, big/small, and others.
7. The learner will observe and describe familiar patterns and cycles (e.g., day/night, seasons, geometric patterns).
8. Presented with an unfamiliar occurrence or setting, the learner will make accurate observations without exaggeration.
9. Given an object or organism or a facsimile, the learner will be able to describe it in such detail that another learner may identify the object or organism from the description.

Grade Level	Scientific Inquiry	Scientific Knowledge	Conditions for Learning Science	Applications for Science Learning
Grade One	**The learner will:**	**The learner will:**	**The learner will be:**	**The learner will be:**
	● make multiple observations of events and explorations using their five senses. ● investigate and discuss measurement using standard and non-standard units. ● make simple graphs (e.g., histograms, pictographs) of observations with the aid of various technologies and real objects. ● seek information from many different sources.	● explore simple models of very large and very small objects that can be made from simple familiar materials (e.g., clay, sand, paper, wood). ● explore different factors that affect the rate of change in the attributes of organisms and objects (e.g., melting of ice, changing leaves). ● explore observable patterns in their lives (e.g., seasons, day/night cycles).	● selecting material related to science, technology, topics and questions of personal interest (e.g., print, audiovisual, electronics). ● discussing events (both short and long duration) that occur in the learning environment when they occur. ● meeting persons who use science and discussing the science they use.	● searching for and collecting information from a variety of sources on topics of interest to complete a task (e.g., library collections, hobby collections, stories and legends, pictures, persons). ● discussing the reasonableness of legends, stories, fantasies, and dreams presented in books, television, radio, and cartoons. ● constructing carefully designed and useful items (e.g., bird feeders, book ends, doll houses, door stops, and others).

Grade Level

Grade One

Scientific Inquiry

The learner will:

- ask "What if..." questions and explore multiple possible explanations.
- persist at simple tasks.
- test ideas using physical materials and models.
- make and organize collections individually and collaboratively.
- conduct simple explorations based on his/her own questions.
- examine existing knowledge by asking 'Why?' and 'How do we know?'
- respectfully consider the ideas and impressions expressed about natural events by others.
- record ideas, data, and events by using a variety of media (e.g., computer, audio, video, visual arts).

Scientific Knowledge

The learner will:

- explore the abilities of some objects to influence other objects (e.g., wind, magnets, static electricity, and others).
- explore his or her own classification schemes to distinguish among and between objects and organisms in terms of observable physical properties.
- explore similarities and differences observed in a wide diversity of objects and organisms.
- explore the concepts of time (e.g., before, after, and during).
- explore drawings and models of very large and very small objects.
- explore different ways (e.g., orally, pictorially) of asking different kinds of questions (e.g., who, what, where, why, when and how?).

Conditions for Learning Science

The learner will be:

- exploring ideas over extended periods of time.
- taking time to redesign and repeat investigations.
- exploring discrepant events.
- investigating indoor and outdoor environments.
- experiencing and describing food in sensory terms.
- exploring and discussing natural phenomena with older and younger learners in small- and large-group settings.
- using keyboards (e.g., games, calculators, computers, musical instruments) to express ideas.

Applications for Science Learning

The learner will be:

- practicing appropriate conservation of materials and waste disposal.
- resolving personal disputes and making decisions.

Performance Objectives: Grade One

1. Given a situation in which a physical change is evident, the learner will observe and describe the physical change.
2. The learner will follow a simple set of instructions to construct a useful item (e.g., bird feeder, doorstop).
3. Given a set of familiar objects, the learner will design and describe categories and use them to organize the set.
4. Presented with unfamiliar situations or phenomena, the learner will ask questions related to cause and effect.
5. Given a familiar but unordered sequence of pictures that represent a physical change, the learner will describe the sequence using terms such as before, during, and after.
6. The learner will use a classification system that he/she has previously developed to classify a new set of items, citing modifications of the systems as necessary.
7. The learner will observe events in which the causes of the effects are not observable (e.g., illness, magnets, respiration rate, static electricity, wind), and ask questions about their effects.
8. Given a simple question regarding natural phenomena, the learner will suggest several places to find information that may lead to answers to the questions.
9. Provided with a suggested familiar organism, the learner will describe or draw a picture of a simple home for the organism and describe its contributions to meeting the needs of the organism.
10. Provided with a familiar object, the learner will describe the potential safe uses of the object.

Grade Level

Grade Two

Scientific Inquiry

The learner will:

- recognize the limitations and variability of descriptions of objects and events within the range of human senses.
- solve problems and resolve issues using varied strategies, including observing, questioning, manipulating objects, discussing, and others.
- design, describe, and carry out simple cause and effect investigations.
- ask "How do we know…" questions about objects, events and phenomena.
- identify sequences of events.
- restate, illustrate, or summarize what others have said.
- use a variety of media to search for information.
- design, conduct, and repeat explorations.
- ask 'Why?'
- use a variety of instruments to measure and observe.

Scientific Knowledge

The learner will:

- explore ways in which organisms and objects react to changing conditions around them (e.g., hibernation, migration, animals shedding, weathering, phase changes).
- explore observable patterns in their lives (e.g., musical scales, reflected light, the phases of the moon).
- explore components and the roles of those components within technological, social, and ecological systems (e.g., toys and tools, families and school groups; habitats, lots and playgrounds).
- explore the diversity of and interactions between living things and non-living things.
- explore the varied needs of living things (e.g., water, nutrients, space, light) and the different ways in which living things meet their needs.
- explore estimates and comparisons of the passage of time and duration of phenomena, the sizes of objects and organisms, and the distances between objects.

Conditions for Learning Science

The learner will be:

- individually and collaboratively developing multimedia expressions of ideas and explanations.
- exploring organisms that share indoor and outdoor environments.
- contributing in a variety of ways in small- and large-group activities (i.e., recorder, reporter, materials manager, encourager).
- reading and writing stories about famous men and women in science history.
- discussing ideas about events that have occurred at home.
- taking time to reflect on observed events.
- interviewing and interacting with community members to discuss past events and developments in science and technology.
- selecting appropriate technologies to extend the senses, perform tasks, and express ideas.
- developing and conducting investigations collaboratively and critiquing the results.

Applications for Science Learning

The learner will be:

- inventing and testing creative procedures and devices.
- discovering ideas and inventions from a wide diversity of persons, cultures, and other sources.
- making appropriate choices regarding the capacity of containers, uses of tools, characteristics of materials, amounts of time, procedures required for tasks, and others.
- utilizing technological devices for various purposes. (e.g., computers, videocameras, tape recorders, cameras, musical instruments, computer-based systems).
- making choices regarding personal wellness (e.g., cleanliness, bicycle safety, household safety).

Grade Level	Scientific Inquiry	Scientific Knowledge	Conditions for Learning Science	Applications for Science Learning
Grade Two	The learner will:	The learner will:	The learner will be:	The learner will be:
		■ explore the effects of the use of optical devices on their own observations of the world (e.g., hand lens, telescope, prism). ■ explore the use of various scales as they are applied to making observations (e.g. thermometers, rulers, color wheels, musical scales). ■ explore questions of differing focus (e.g., Who?, What?, Where?, When?, Why?, How?).	■ role-playing re-creations of systems and discussing reasons for the actions of parts of the systems dramatized. ■ participating in discussions with peers. ■ reporting the results of explorations and inquiries using a variety of media in various settings. ■ exploring the similarities and differences in the use of technology in various cultures.	

Performance Objectives: Grade Two

1. The learner will observe living organisms (animals or plants) in the classroom and make several predictions related to their behavior or response to a stimulus.
2. Given the results of a simple investigation, the learner will suggest several new questions to investigate.
3. The learner will discuss the basic needs of living things and describe the ways that organisms meet these needs.
4. Given a season of the year or local weather conditions the learner will predict how different organisms will react.
5. Given an array of comparative scales and objects appropriate to the scales, the learner will contrast objects and suggest improvements in the scale being used.
6. Shown a natural event, the learner will ask several questions related to what happened and what may have caused it to occur.
7. The learner will use an electronic instrument to record an event.
8. The learner will select and use appropriate materials and tools to construct a useful device.
9. The learner will compare the mass, dimensions, and volume of familiar objects and organisms using nonstandard measures.

Grade Level

Grade Three

Scientific Inquiry

The learner will:

- search for information from multiple sources.
- select and explore the use and accuracy of a variety of measuring devices.
- predict what is missing and what will come next in sequences of objects and events and test his/her predictions.
- speculate on commonly held assumptions about events and phenomena in their world.
- explore the importance of various habits of mind (e.g., honesty, ethics, openness, skepticism, concern for health and safety) in making observations, reports, and decisions.
- observe events and phenomena of varying duration and report occurrences accurately and ethically.
- explain and discuss various influences affecting observations and interpretations.
- apply common arithmetic operations to whole number counts and measures of concrete objects and observations to increase understanding and accuracy of descriptions and interpretations.

Scientific Knowledge

The learner will:

- explore motions of objects and organisms.
- explore the capacity of some objects and organisms to influence other objects and organisms (e.g., air, magnets, static electricity, light and sound sources, predators, pesticides, soil, water).
- explore the relative contributions of each component (part) in a system (whole).
- explore qualitative and quantitative descriptions of objects and organisms.
- explore collections in various forms that represent the diversity of living things and non-living things.
- explore estimations of observable time (e.g., minutes, hours, days, weeks).
- explore qualitative estimates of the rates of change (e.g., faster, slower, tone, brightness, loudness, cooling, and heating).
- explore various resources for investigating questions (e.g., written materials, authorities, databases, libraries).

Conditions for Learning Science

The learner will be:

- working collaboratively with peers and learners of different ages and talents in various places.
- exploring and investigating systematically observed natural phenomena in indoor and outdoor settings over a variety of time spans.
- repeating explorations and events safely.
- identifying and choosing topics and units for study.
- expressing ideas and observations made in other settings in small- and large-group settings.
- dramatizing milestones in the history of science.
- using constructed physical models and dioramas to express ideas and conceptions of events and phenomena.
- using mathematics and language arts as tools to build models and express ideas.
- participating in individual and group design of explorations.
- examining and reflecting upon personal perspectives regarding natural events.

Applications for Science Learning

The learner will be:

- obtaining information from the environment. (e.g., weather instruments, thermometers, sundials, gauges, timers).
- exploring the origins of devices found in the home or classroom setting.
- exploring unknowns in the natural world.
- manipulating the amounts and combinations of ingredients to observe the impact of different combinations on the effectiveness of common household products and quality of foods.
- choosing and preparing for outdoor activities based on environmental conditions.
- contrasting the scientific ideas of many cultures.
- identifying issues that affect settings larger than their immediate local area (e.g., recycling, reduced consumption, polution and personal health).

Grade Level	Scientific Inquiry	Scientific Knowledge	Conditions for Learning Science	Applicationsfor Science Learning
Grade Three	The learner will:	The learner will:	The learner will be:	The learner will be:
	seek evidence to support ideas by asking "How does it work?", "How do we know?", and "Why?" use computers and other technologies to express ideas and collect data. use observed qualitative and quantitative attributes to describe phenomena. take responsibility for the care of supplies and equipment used in explorations. identify potential hazards and safely conduct explorations and activities.		using various modes of communication to effectively express their ideas. writing "day in the life of..." stories about real or imaginary scientists. engaging scientists in discussions about their occupations. exploring his/her own technological heritage from evidence found at home. constructing a portfolio of products and evaluations of his/her own abilities, skills, and experiences including self evaluations.	

Performance Objectives: Grade Three

1. The learner will decide what information is necessary to make a simple weather report, collect the information, and make the report.
2. Given a collection of evidence resulting from an event, the learner will seek clarification, and propose an explanation for the event.
3. The learner will describe an episode (e.g., storms, rolling and bouncing balls, hatching eggs, falling maplecopters) in terms of its duration and timing.
4. The learner will use whole number counts and measures to compare and classify familiar objects.
5. Given several opportunities to observe, the learner will use both quantitative and qualitative descriptions to explain the attributes and behaviors of an object or organism.
6. The learner will choose a sense-extending device to gather information from observations of an object, event, or organism.
7. Given a diverse collection of living and non-living things, the learner will distinguish between living and non-living things and provide justification for this classification.

Grade Level

Gradè Four

Scientific Inquiry

The learner will:

- utilize caution and demonstrate care and concern for ones self, classmates, equipment, specimens and the environment when making observations, conducting experiments and participating in group interactions.
- choose measurement methods and devices according to the level of precision demanded by the task.
- make reasonable and accurate scale readings while utilizing equipment to collect information and describe observations (e.g., simple thermometers, timers, magnifiers, rulers, measuring cups, balances, and others).
- select and use mathematics tools such as numerical manipulation (e.g., whole numbers and simple everyday fractions), geometric figures (e.g., circles, rectangles and triangles), and representational charts (e.g., simple pie and bar charts, and pictographs) to measure, count, order, sort, identify, describe, label and communicate information from observations.

Scientific Knowledge

The learner will:

- explore patterns in their lives (e.g., phases of the moon; the water cycle; growth; waves on water, drum heads and strings).
- explore the adaptability and reactivity of individual components of technological, social, and ecological systems and stresses on those systems (e.g., pollution and destruction of habitats, natural disasters, mechanical failures of cycles and transportation systems).
- explore the diversity and scale of various objects and organisms.
- explore the interactions of objects and organisms in simple systems.
- explore and compare the composition and level of organization of objects and organisms (e.g., tissues, organs, organisms, crystals, minerals, and rocks).
- explore and construct simple keys of objects and organisms.
- explore the limitations and usefulness of models and other representations of objects, organisms, and phenomena.

Conditions for Learning Science

The learner will be:

- comparing and contrasting various accounts of historic milestones in science.
- participating in multi-age group investigations in the classroom, the home, the community, and natural environments.
- collaborating with others to construct meaning.
- participating in the selection of topics and themes for exploration.
- reporting with clarity and accuracy all phases of explorations.
- choosing appropriate materials for explorations.
- listening to, reflecting upon, and discussing the ideas and expressions of others.
- participating in group critiques of investigative results.
- examining the results of explorations and repeating the explorations to verify results.
- communicating the results of explorations to others.

Applications for Science Learning

The learner will be:

- discussing the reasonableness of legends, stories, dreams, and tabloid stories presented in the mass media.
- determining the nutritional value of foods in his/her diet.
- using information found in graphs, tables, and articles in newspapers, magazines, television, and other mass media to make decisions.
- analyzing the usefulness of information, considering the historical and cultural context of stories, theories, and accounts, regarding scientific ideas and phenomena, and technological developments.
- solving problems of personal interest that can be addressed scientifically.
- writing and following instructions (e.g., recipes, procedures, assembly instructions, sketches).
- following simple procedures to create products (e.g., models, devices, events, meals, complete tasks).
- designing, inventing, building and sharing projects individually and collaboratively.

Grade Level	Scientific Inquiry	Scientific Knowledge	Conditions for Learning Science	Applications for Science Learning
Grade Four	**The learner will:**	**The learner will:**	**The learner will be:**	**The learner will be:**
	make numerical estimates of answers to problems arising from investigations of natural phenomena and everyday experiences. describe and order objects and events in terms relative to time and space (e.g., bigger, above, inside, older, before). consider the subjectivity of human observations (e.g., bias, opinions, preconceptions, predispositions, experience, limits of the senses). speculate on commonly held assumptions from multiple perspectives (e.g., historical, cultural, societal, aesthetic). formulate personal explanations and inferences on verifiable data. ask "Why?" and "How do you know?" share results of explorations and compare investigative results with other groups.	explore various ways of describing and measuring rates of change and duration of phenomena. explore mathematical expressions of quantities (e.g., sums and differences). explore the form and functions of various historically significant technologies (e.g., bicycle, wheels, balls, scissors, kite). explore the directionality of events and phenomena in terms relative to time and space (e.g., the spreading of a virus; the propagation of a wave; weathering, erosion, and plate tectonics; burning of a piece of paper; wind; diffusion of a fragrance; melting of ice; rolling a ball on various surfaces; collisions between rolling balls).	using library, distance learning, and community resources. discussing personal interests about the natural world in small- and large-group settings. spending time examining phenomena outside of the classroom setting. contributing to developing group agreement on patterns, trends, cycles and relationships by comparing and contrasting the contributions of each of the group members. exploring the interactions of technology and humans using appropriate resources and strategies (e.g., museums, interviews, written information services). using multimedia and human contacts to explore how different cultural factors influence the perceptions of science around the world. contributing to developing group agreement on patterns, trends, cycles and relationships by comparing and contrasting the contributions of each of the group members.	using various techniques (e.g., drawings, sketches, summaries, technology) to clarify and simplify descriptions of explorations.

Performance Objectives: Grade Four

1. Given a repetitive pattern in nature (e.g., sound waves, seasons, phases of the moon, growth rings in a tree), the learner will describe the duration and timing of the pattern.
2. The learner will discuss the impact of human activity in selected natural environments.
3. Given a diverse but familiar set of objects, the learner will prepare a simple key for another learner to use to distinguish between objects in the set.
4. The learner will identify an example of an improbable, illogical event in a selected story and point out contradictions.
5. Given a series of related events, the learner will analyze the series and predict the next likely event.
6. Given a set of counts of objects or observations, the learner will construct a graphic representation and use it to make simple comparisons.
7. The learner will create and follow a simple procedure to carry out an investigation.
8. The learner will propose reasons why observations made by another learner may be different than hers/his.
9. Given a collection of working devices (e.g., scissors, shovel, crowbar, wheel, can-opener, bottler-opener), the learner will explain the function of a selected device and comment on its safe use.

Grade Level	Scientific Inquiry	Scientific Knowledge	Conditions for Learning Science	Applications for Science Learning
Grade Five	**The learner will:**	**The learner will:**	**The learner will be:**	**The learner will be:**
	■ perceive and describe complex structures and events using appropriate concepts (e.g., geometric configuration, duration, rate of change, limit, cause and effect, and constancy).	■ investigate the impacts of various forms of mechanical and electromagnetic waves on various organisms and objects. ■ investigate the regularity of motion found in the interactions in the solar system (e.g., seasons, tides, planets, moons).	■ gathering and evaluating information related to science topics from multiple sources. ■ using reading, writing, and mathematics as tools for learning. ■ communicating and conducting investigations through global networks.	■ assessing potential hazards and take appropriate actions to ensure the safety of himself/herself, and others. ■ selecting consumer products based on performance evaluations using appropriate criteria (e.g., nutrition, safety, energy consumption, environmental impact, essentiality).

Grade Level

Grade Five

Scientific Inquiry

The learner will:

- take responsibility for the care of supplies and equipment used in investigations.
- determine the likelihood of event outcomes, by identifying the causal factors and speculate what additional factors may contribute to a more accurate prediction.
- report findings on the variability of observations accurately and ethically while engaged in scientific inquiry (e.g., controlled experiments and naturally occurring events).
- describe investigative findings to classmates and support the findings with evidence.
- analyze "How do you know?" inquiries in appropriate situations by formulating and investigating reasonable "What might happen if ...?" inquires about everyday experiences.
- invent, describe and carry out simple sampling investigations.
- consider and discuss over time observations and investigations in terms of how they conflict, support, refine, and extend his/her constructed understandings.
- observe discrepant events and propose and test explanations of what happened.

Scientific Knowledge

The learner will:

- investigate conditions that affect the motions of objects and organisms.
- investigate the consequences of changes in roles and contributions of various components of technological, social, and ecological systems.
- investigate the diversity of methods by which living things meet their needs (e.g., food, shelter, protection, respiration).
- investigate the composition and level of organization of objects and organisms (e.g., crystals, minerals, rocks, tissues, organs, organisms).
- investigate various properties of groups of objects and organisms.
- investigate easily measured distances and rates of change and their implications in technological and natural systems.
- investigate the history and function of various techniques and technologies (e.g., sanitation, nutrition, hygiene, friction reduction, erosion control, crop rotation, agriculture).
- investigate the transmission and conservation of various forms of energy through biological and physical systems (e.g., electricity, weather, agriculture).

Conditions for Learning Science

The learner will be:

- constructing a portfolio of products and self-evaluations of his/her own abilities, skills, and experiences.
- contributing to and maintaining a safe, healthful, and efficient learning environment.
- using technologies to collect and store information.
- optimizing the individual contributions made by cooperative group members.
- examining and refining personal understanding of scientific concepts.
- collaborating to prepare and perform individual and group presentations of explorations.
- familiarizing himself/herself with the investigations performed by the global scientific community.
- accepting and generalizing results of investigations based upon repeated observations and multiple sources.
- considering risks and benefits before collecting, displaying, and maintaining organisms in the classroom.
- investigating living and nonliving things holistically through models, simulations, multimedia, technologies.
- maintaining journals of observations and inferences over long periods of time.

Applications for Science Learning

The learner will be:

- exploring the impact of the uses of technology on the environment.
- explaining the operation of everyday devices based upon scientific principles.
- proposing alternatives regarding community issues.
- analyzing and cooperatively working toward resolution of disagreements (e.g., results, procedures, interpretations) during learning activities.
- participating actively in dialogue about community issues.
- undertaking assembly, disassembly, adjustment, and modification activities in the context of the physical setting and living environment.
- taking time to access and effectively using tools, instruments, community resources and devices that will enable investigations to proceed more efficiently.

Performance Objectives: Grade Five

1. Using sense-extending devices, the learner will describe an object or organism not easily observed in terms of its attributes and behaviors.
2. Given data from a simple mechanical or biological system, the learner will describe how changing one component impacts the other components of the system.
3. The learner will propose 'What if . . .?' questions regarding a simple physical change, design and test his/her questions, and cite and justify appropriate safety precautions.
4. The learner will choose a simple technological device and describe the advantages and disadvantages to the user.
5. Given a question about a natural phenomenon, the learner will propose several sources of information that may assist in addressing questions about the phenomenon.
6. The learner will choose and use appropriate tools to assemble and disassemble a simple mechanism or model.
7. Given data on the performance of consumer products, the learner will choose and defend their choice of a product based on performance data.
8. The learner will trace the transmission, transformation, and conservation of various forms of energy in a simple system (e.g., food web, bicycle, kite, scissors, human body).

Grade Level	**Scientific Inquiry**	**Scientific Knowledge**	**Conditions for Learning Science**	**Applications for Science Learning**
	The learner will:	**The learner will:**	**The learner will be:**	**The learner will be:**
Grade Six	share findings and offer explanations for inconsistencies, limitations, and variability in recorded observations from similar investigations carried out at different times in different places, and using different techniques.	investigate the factors that influence the motion of objects and the motions of and within organisms. investigate patterns in nature (e.g., soil ecology, sedimentary rock layers, vibrations in physical materials, reproductive strategies, transfer and transformations of energy, and genealogies).	participating in the selection of topics and themes for class investigation. repeating learner-designed experiments several times to improve the reliability of results through improved experimental design.	making decisions regarding personal wellness by monitoring body system performance. learning, performing, and explaining magic tricks, illusions, and cinemagraphic techniques from a scientific point of view.

Grade Level

Grade Six

Scientific Inquiry

The learner will:

- design and conduct a range of investigations (e.g., observations of objects and events, controlled experiments) associated with everyday experience.
- utilize caution and demonstrate care and concern for ones self, classmates, equipment, specimens and environment when making observations and participating in group interactions.
- measure and mix dry and liquid materials in prescribed amounts, in various settings, exercising reasonable safety.
- select and use appropriate manipulative devices and technologies to collect information directly, choosing appropriate units for measures and reporting diverse magnitudes.
- utilize appropriate units for counts and measures and keep track of them in computations performed by hand, calculator or computer.

Scientific Knowledge

The learner will:

- investigate the limitations of individual components within technological, social, and ecological systems.
- investigate the diversity and scale of various technological and a natural systems.
- investigate and make inferences from collections of artifacts and objects (e.g., fossils, footprints, echoes, photographs, seismic patterns).
- investigate classification systems that are based on attributes that are not readily visible (e.g., electromagnetic radiation, tissues, sounds, minerals, stars).
- investigate various quantitative representations of rates of change and duration of phenomena.
- investigate inferences about large objects, organisms, and systems made from observations of smaller objects, organisms, and systems.
- investigate different versions of historical events in science (e.g., Thomas Edison and the light bulb, Louis Pasteur and pasteurization, Marie Curie and radium, George Washington Carver and peanut butter).

Conditions for Learning Science

The learner will be:

- performing investigations in a community environment (e.g., natural, altered, and built).
- using appropriate terminology in context to discuss investigations of scientific concepts.
- considering the perspectives of others in group investigations of natural phenomena.
- using technologies to investigate and communicate ideas, questions, and information.
- raising issues and engaging in discussions of current scientific issues.
- creating dramatizations and simulations of events to help explain phenomena.
- using a variety of modes of expression to communicate ideas.
- critiquing presentations that utilize propaganda techniques (e.g., irrelevant motivators, half-truths, generalizations).
- asking for evidence that supports or refutes explanations.
- assisting learners of various ages to learn about science concepts and their applications.

Applications for Science Learning

The learner will be:

- evaluating and challenging where appropriate, the claims made in consumer product advertisements.
- making everyday scientific and technological decisions.
- gaining insight into his/her own situation in light of the historical background of important inventions and technologies.
- monitoring and proposing improvements appropriate to the disposition of various types of wastes in the home, school, community, and the environment.
- following step-by-step instructions, recipes, and sketches.

Grade Level	Scientific Inquiry	Scientific Knowledge	Conditions for Learning Science	Applications for Science Learning
	The learner will:	The learner will:	The learner will be:	The learner will be:
Grade Six	• select and use math tools such as numerical manipulation (e.g., whole, fractions, decimal equivalents), geometric figures (e.g., circles, rectangles, triangles, ellipses, planes, spheres, rectangular solids), and simple tables, graphs and representational charts (e.g., simple line graphs, pie and bar charts, pictographs) to measure, count, order, sort, identify, describe, label and communicate information from observations. • apply appropriate mathematical operations to make mental estimates of the reasonableness of measures of everyday observations and events. • make, interpret, and use scale drawings, maps, and models. • formulate explanations and inferences and make decisions on verifiable data.	• investigate various resource cycles in physical and biological systems (e.g., carbon, nitrogen, water). • investigate various impacts of biological and geological activity on the earth. • investigate the reversability of phenomena and events in terms relative to time and space (e.g., changes of phase, collisions, rechargeable batteries).	• maintaining a journal over an extended period of time in which observations are recorded and inferences are noted. • identifying and addressing scientific issues of local and global importance. • meeting and working with people engaged in scientific and technological careers.	

Performance Objectives: Grade Six

1. The learner will predict and test the effects of influences on the motion of selected objects (e.g., rubber band-powered vehicles, hygrometers, sailboats, tropisms, flowing water).
2. Provided with examples of patterns in natural phenomena (e.g., period of a pendulum, variation in populations, the spread of disease, Logo fractals, position of the moon, reflection, refraction, interference patterns), the learner will design and perform an investigation to document the constancy of the pattern.
3. The learner will identify a community problem (e.g., recycling, water quality, animal and plant overpopulation and competition, extinction, urban growth, soil conservation, transportation issues, physical recreation opportunities) and propose a solution for that problem using information collected to support their proposal.
4. Given a collection of data presented in tabular or graphic form, the learner will make inferences to explain the events or phenomena from which the data was collected.
5. Given the observations of witnesses and related evidence, the learner will identify the impact of different perspectives on explanations of an event.
6. Presented with different versions of a historical event in science or technology, the learner will discuss the impact of scientific and social context at the time of the event.
7. Given a set of data and a set of attendant conclusions, the learner will verify or refute the accuracy of the conclusions.

Grade Level	Scientific Inquiry	Scientific Knowledge	Conditions for Learning Science	Applications for Science Learning
Grade Seven	The learner will:	The learner will:	The learner will be:	The learner will be:
	predict what might be wrong with an experimental design when observations vary widely, and propose and execute design changes to correct these problems. analyze a variety of divergent explanations for similar natural phenomena. store, retrieve and manipulate information with a computer, using various files types (e.g., topical, alphabetical, numerical, key-word files) and use simple files of their own design. utilize mathematical models (e.g., number lines, graphs, and charts) for exploring, organizing and displaying information and identifying trends and patterns. utilize analogies to understand how things work. make and accurately record observations, inferences, hypotheses, experiences, ideas, and explanations. find and read facts and figures in news media, books, or databases, make sense of them, and construct appropriate lists, tables, or graphs.	investigate principles which describe the impacts of various forms of mechanical and electromagnetic waves on various organisms and objects. investigate patterns in nature (e.g., vibrations, probabilities, behaviors, growth, migrations, energy transmission and transformation). investigate resistance to change in natural and technological systems (e.g., dynamic equilibrium, inertia, electrical resistance). investigate the interactions of objects and organisms in simple technological and natural systems. investigate qualitatively the geometry and regularity of motion found in interactions in the solar system (e.g., planetary motion, comets, satellites). investigate the organization within and among the atmosphere, hydrosphere, lithosphere and celestial sphere. investigate the properties of new materials as compared with those of the familiar materials.	using a diversity of writing styles to communicate scientific ideas. using primary sources and interviews to examine the history of science concepts. seeking explanations for conflicting descriptions of the same event. observing and discussing the process of community decision making. investigating living and nonliving things holistically and by component structures and functions through (e.g., models, simulations, multimedia, technologies, evidence collection). using multimedia and human contacts to investigate how different cultural factors exert influences on scientific perceptions around the world. maintaining records of group investigations (e.g., accounts of processes, results, individual contributions). visiting community workplaces to examine applications and reinforce understanding of scientific concepts.	writing and following instructions (e.g., algorithms, formulas, flow diagrams, and sketches). designing, building, and testing working models of structures and systems. differentiating between the scientific and non-scientific information found in folklore. choosing everyday consumer products that utilize recent innovations (e.g., polymers, silicon chips, computer software). making decisions in light of possible outcomes of different genetic combinations of inherited characteristics. choosing, modifying, and inventing tools, instruments, devices, computer-based technologies and procedures that enable student developed investigations to proceed more efficiently. analyzing advertisements and technical information to recognize biases and misrepresentation of scientific information.

Grade Level	Scientific Inquiry	Scientific Knowledge	Conditions for Learning Science	Applications for Science Learning
Grade Seven	**The learner will:**	**The learner will:**	**The learner will be:**	**The learner will be:**
	• recognize regular occurrences in nature and describe various spatial, behavioral, temporal patterns; formulate their own explanations for them; and offer evidence for their explanations, while remaining open to alternative explanations of others in the group. • organize information into simple tables or graph to look for relationships.	• investigate the interdependence and similarities of organisms and their physical environments (e.g., mimicry, camouflage). • investigate the chemical and physical attributes of matter. • investigate the scale of historical time (e.g., years, decades, centuries). • investigate the limits of size in technological and natural systems. • investigate the renewable and nonrenewable nature of the earth's resources and various strategies for managing these resources.	• asking for clarification of scientific ideas. • using available communications technology to consult authorities for information and clarification (e.g., letters, phones, electronic networks, satellite telemetry) • weighing the biases of information sources.	

Performance Objectives: Grade Seven

1. The learner will analyze and critique the science presented in the media (e.g., periodicals, advertisements, literary works, cinema, public documents).
2. The learner will design and use procedures to test the suitability of various materials for different purposes.
3. The learner will choose and use appropriate technologies to collect observations regarding a complex system (e.g., the atmosphere or an ecosystem) and use the observations to make predictions about the effects of changes made in various components of the system.
4. Presented with data on the consumption pattern of a resource in the local community, the learner will propose (e.g., written proposal, persuasive materials, videos) a strategy to manage the resource more efficiently and economically.
5. The learner will construct, test, and trouble-shoot a set of procedures for younger learners to use to investigate a common natural phenomenon.
6. Given a set of data on an event or phenomenon, the learner will summarize the data in several meaningful ways (e.g., graphs, tables, narratives, models).
7. The learner will use scientific terminology appropriate to their developmental level to make predictions in a complex system (e.g., weather, ecosystems, inertial, energy).

Grade Level

Grade Eight

Scientific Inquiry

The learner will:

- use complex concepts to describe structures and events (e.g., geometric configurations, duration, rates of change, limits, cause and effect, constancy, conservation, dissipation).
- approximate various irregular areas and volumes of solids by various means (e.g., graphical, physical).
- identify statements that are misleading because they are absolute or general in nature (e.g., use a celebrity as an authority, or use vague attributions in place of specific references like "Leading physicists say...", "Everybody knows...", "Statistics show...").
- determine the likelihood of events, by identifying contributing and causal factors and estimate the confidence level of predictions.
- estimate lengths, weights, and time periods and judge whether the estimates or computations are reasonable.
- develop increasingly sophisticated logical thinking strategies (e.g., "If...Then" logic).
- produce quality instructions, recipes, maps, and plans for use in learning activities.

Scientific Knowledge

The learner will:

- investigate the principles that describe and predict motions of objects and functions of organisms.
- investigate the influences of groups of objects, organisms and forms of energy on each other (e.g., light, sound, electricity and magnetism, heat, earth processes, predators, pesticides).
- investigate strategies that can be used to optimize the interactions between components of technological, social, and ecological systems (e.g., recycling, neutralizing, stress and friction reduction, buffering, modulating, impedance matching).
- investigate patterns in nature (e.g., symmetry, reflected and refracted light, life cycles, harmonic motion).
- investigate the heritability of attributes and the maintenance of diversity through a variety of reproductive strategies.
- investigate various standard classification systems (e.g., the periodic table, Linnean classification, the HR series).

Conditions for Learning Science

The learner will be:

- suggesting and selecting topics and strategies for investigation.
- constructing, clarifying, and extending questions to improve investigative methods.
- examining, and discussing different perspectives on physical and biological phenomena.
- participating in group investigations of activities that include learners of different ages.
- using activities, resources and concepts from other disciplines in investigations to broaden, enrich, and support his/her understandings.
- identifying issues and utilizing experts and information to generate courses of action for resolving community issues.
- assisting others (e.g., peers, persons younger and older) in doing tasks, solving problems, and understanding concepts.
- using community resources to collect and analyze consumer product information.
- communicating clearly scientific questions, purposes, procedures, and results.

Applications for Science Learning

The learner will be:

- resolving issues of personal interest, health, and safety utilizing various strategies (e.g., asking informed questions of authorities, formulating testable hypotheses).
- using, consuming, and disposing of consumer products properly .
- advocating the consideration of intersystem relationships (e.g., environmental, economic, social, industrial).
- making decisions based upon the risks and benefits associated with various resource utilization and waste management strategies.
- recognizing and pursuing questions related to choices that can be investigated scientifically.
- implementing appropriate wellness strategies that will contribute to personal satisfaction and growth.
- planning menus and choosing products in light of various food production and consumption practices in different cultures.

Grade Level	Scientific Inquiry	Scientific Knowledge	Conditions for Learning Science	Applications for Science Learning
Grade Eight	The learner will:	The learner will:	The learner will be:	The learner will be:
	perform risk analyses to inform personal decisions associated with personal safety and health. formulate personal explanations and inferences based on reliable data. modify personal behaviors and understandings of scientific principles based on new information, experiences, and interactions with other learners. apply accepted ethical standards to the treatment of the subjects of investigations. collect and analyze information from phenomena utilizing various techniques and technologies (e.g., slides, flash photography, videotape, multimedia, computer-based sampling devices, and simulations).	investigate historical understandings of the conservation of matter and energy (e.g., Lavoisier, Watt, Joule, Einstein). investigate composition and level of organization of objects and organisms (e.g., rocks, minerals, compounds and elements; organisms, systems, organs, tissues, and cells). investigate models of macromolecular structures and the physical and biological implications of these structures (e.g., enzymes, DNA, hemoglobin, polymers). investigate models and theories of change over time (e.g., natural selection and speciation, stellar evolution, plate tectonics, the rock cycle). investigate very large scale objects, quantities, and phenomena (e.g., galaxies, glaciation, watersheds, the speed of light, interplanetary distances). investigate concepts involving large and small time spans (e.g., hazardous waste disposal, relative life spans of stars and organisms, plate tectonics). investigate evidence of relative motion between and among objects (e.g., doppler effect, frames of reference). investigate dichotomous keys for artifacts and objects.	listening carefully to and analyzing the proposals and arguments of others. recognizing and critiquing presentations that lack distinction between fact and opinion. performing investigations over long and short time periods. performing investigations responsibly and safely in a safe and healthful environment. constructing a portfolio of products and self-evaluations of his/her own abilities, skills, and experiences.	manipulating the amounts and combinations of ingredients to observe the impact of different combinations on the effectiveness of common household products and quality of foods.

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Performance Objectives: Grade Eight

1. Presented with a structure or series of events (e.g., amusement park rides, changes of phase, porosity, permeability, toxicity, hazardous waste removal, enzymes, oxidation and reduction, threshold limits), the learner will analyze features related to the constancy and rates of change represented.
2. The learner will construct a simple working model (e.g., Rube Goldberg apparatus, simple vehicles, energy conservation systems, stream tables, terraria, aquaria) of a macro-scale phenomenon.
3. Presented with data on the motion of several objects (e.g., celestial bodies, freely falling objects, projectile motion, vehicular motion), the learner will construct a visual representation that can be used to predict the motions of the objects at subsequent times.
4. Given a learner-identified issue of local community importance (e.g., air pollution, pesticides, chemical exposure, radon, abandoned hazardous waste sites, transmission lines, landfills), the learner will collect information and observations and take action on a decision made regarding the issue.
5. Provided with several objects or organisms and the appropriate key, the learner will identify the organisms or objects.
6. Given data collected by self and others regarding changes over long time frames (e.g., corrosion, succession, erosion, glaciation), the learner will construct a model of the changes that have occurred.
7. The learner will create a blueprint, sketch, or map (e.g., street, topographic, electric field, magnetic field, acoustical, thermal) for other learners to use and follow directions using a blueprint, sketch, or map provided by other persons.
8. The learner will construct a device or tool (e.g., exercise machine, robot, periscope, computer, radio, scissors, vehicle) that takes advantage of or enhances personal performance.

Grade Level	Scientific Inquiry	Scientific Knowledge	Conditions for Learning Science	Applications for Science Learning
	The learner will:	**The learner will:**	**The learner will be:**	**The learner will be:**
Grade Nine	■ check the appropriateness and accuracy of measures and computations using various strategies (e.g., estimations, unit analysis, determination of significant figures). ■ use ratios, proportions, and probabilities in appropriate problem situations.	■ investigate various types of dynamic equilibrium (e.g., biological, geological, mechanical, chemical). ■ investigate the relationship between the rates of energy exchange and the relative energy level of components within systems (e.g., trophic levels of ecosystems, osmosis, rate of heating and cooling, storms).	■ participating actively in dialogue about and resolution of community issues. ■ accessing information from various countries in the original language or translated form to ascertain the perspectives of many cultures. ■ analyzing the scientific ideas presented in science fiction stories and films.	■ answering student-determined questions by designing databases and drawing inferences from the analyses of the information in these databases. ■ making personal behavior decisions by interpreting information that has a scientific basis.

Grade Level

Grade Nine

Scientific Inquiry

The learner will:

- translate information from and represent information in various forms with equal ease (e.g., tables, charts, graphs, diagrams, geometric figures).
- use existing algebraic formulas and create new ones in appropriate problem-solving situations.
- estimate and justify probabilities of outcomes of familiar situations based on experimentation and other strategies.
- invent apparatus and mechanical tools needed to perform unique tasks in various situations.
- identify, compare, and contrast different modes of inquiry, habits of mind, and attitudes and dispositions.
- design investigations that are safe and ethical (i.e., obtain consent and inform others of potential outcomes, risks and benefits, and show evidence of concern for human health and safety, concern for non-human species).
- make and read scale drawings, maps, models, and other representations to aid planning and understanding.

Scientific Knowledge

The learner will:

- investigate patterns in the natural world (e.g., heredity, crystaline structures, population and resource distributions, diffraction, dispersion, polarization).
- investigate models and theories that help to explain the interactions of components in systems (e.g., conservation of mass, energy, and momentum; foodwebs; natural selection; entropy; plate tectonics; chaos; relativity; social-psychology).
- investigate degrees of kinship among organisms and groups of organisms.
- investigate the limits of the definition of life, and investigate organisms and physical systems that exist at or near these limits (e.g., viruses, quarks, black holes).
- investigate estimates and measurements of a wide range of distances and rates of change.
- investigate the historical development of theories of change over time (e.g., natural selection, continental drift, the big bang, geologic change).

Conditions for Learning Science

The learner will be:

- performing and repeating investigations to verify data, determine regularity and reduce the impact of experimental error.
- presenting the results of investigations in a variety of forums.
- contributing to the decisions regarding topics for investigation.
- using various creative means to communicate interpretations of scientific ideas, concepts, phenomena and events.
- considering the scientific thinking and language of others.
- individually and collaboratively producing clearly written representations of investigative results.
- fulfilling responsibilities as part of a research group.
- selecting and utilizing resources by various criteria (e.g., efficiency, effectiveness, health, safety) that are appropriate to the investigations being conducted by groups.
- presenting persuasive argument based on the scientific aspects of controversial issues.

Applications for Science Learning

The learner will be:

- proposing courses of action that will validate and demonstrate personal understandings of scientific principles.
- guiding other learners in their understanding of the interactions of technologies and society at various periods in time.
- promoting and carrying out practices that contribute to a sustainable environment.
- studying and proposing improvements in public services and systems in their community.
- choosing consumer materials utilizing personal and environmental risk and benefit information.
- making inferences, and drawing conclusions using databases, spreadsheets, and other technologies.
- doing simple trouble-shooting on common electrical and mechanical systems, identifying and eliminating possible causes of malfunctions.
- constructing devices that perform simple, repetitive actions.

Grade Level	Scientific Inquiry	Scientific Knowledge	Conditions for Learning Science	Applications for Science Learning
Grade Nine	The learner will:	The learner will:	The learner will be:	The learner will be:
	• seek elaboration and justification of data and ideas, and reflect on alternative interpretations of the information. • utilize appropriate units for counts and measures.	• investigate physical and chemical changes in living and non-living systems (e.g., photosynthesis, weathering processes, glaciation, thermal effects on materials, energy cells). • investigate simulations of nuclear change (e.g., radioactivity, half life, carbon dating). • investigate conservation principles associated with physical, chemical, and nuclear changes.	• collecting, storing, retrieving and manipulating information with available technologies that may range from hand processes up through computer applications.	• investigating the functionality of various geometric shapes in the natural world and the designed world (e.g., translations from spherical to plane representations cause distortions, triangular shapes contribute to rigidity and stability in structures, round shapes minimize boundary for a given capacity).

Performance Objectives: Grade Nine

1. Presented with appropriate charts, graphs, and other representations of changes in a dynamic system (e.g., rates of reaction, absorption and emission, homeostasis, momentum, energy, ecological balance in nature, carrying capacity, energy cells, climate, displacement and velocity) the learner will describe the type and rate of change represented.
2. The learner will test a physical or mathematical model of a pattern, structure, or behavior (e.g., energy content of foods, gas laws, conservation of energy and momentum, home energy consumption, planetary motion, earthquakes, circuit laws, genetic probabilities).
3. The learner will collect data on variability in a dynamic system (e.g., metabolic data, resistance to infection, spectra from various sources, reflection and refraction with various materials, moisture capacity of the air, planetary orbits, changing strategies for energy production and use, the Bernoulli principle, the doppler effect) and explain how the system remains predictably constant.
4. The learner will access primary and secondary data from remote sources (e.g., weather satellites, radio telemetry, seismographs, radar, sonar) and make inferences and predictions that are possible from that data.
6. Given a learner-identified potential hazard (e.g., ground water contamination, air poluution, disposal of hazardous wastes), the learner will design an investigation of the hazard, collect data in the form of surveys and empirical data as a member of a research team, and present the results of the investigation.
7. The learner will compare and contrast diverse structures and their associated functions (e.g., geological formations, chemical structures, engineered structures, ecosystems, subatomic structures).
8. Presented with different versions of a historical event in science or technology (e.g., Wallace and Darwin and natural selection, Edison and Tesla and electric current, Lyell and Wegener and geological theories), the learner will discuss the impact of social and scientific context at the time of the event.

Grade Level

Grade Ten

Scientific Inquiry

The learner will:

- create and use databases (electronic and other) to collect, organize, and verify data and observations.
- design and conduct investigations with multiple variables.
- communicate the results of investigations clearly in a variety of situations.
- discuss societal controversies that surround scientific issues.
- examine relationships in nature, offer alternative explanations for the observations, and collect evidence that can be used to help judge among explanations.
- trace the development (e.g., history, controversy, and ramifications) of various theories, focusing on supporting evidence and modification with new evidence.
- select, invent, and use tools, including analog and digital instruments, to make and record direct measurements.
- observe and document events and characteristics of complex systems.

Scientific Knowledge

The learner will:

- formulate descriptions of the impacts of various forms of mechanical and electromagnetic waves on various organisms and objects.
- formulate models and hypotheses for patterns in the natural world (e.g., earth structures, transportation systems, migrations, communications, constellations).
- formulate explanations for the influences of objects and organisms on each other over time.
- formulate and interpret explanations for change phenomena (e.g., mass extinctions, stellar evolution, punctuated equilibrium, molecular synthesis).
- formulate and interpret explanations for the magnitudes of diversity at different periods of geologic time (e.g., mutation, global cataclysms, continental drift, competition, mass extinctions).
- formulate interpretations of the structure, function and diversity in a variety of organisms and physical systems. (e.g., DNA and RNA variants, nucleons, interaction particles).

Conditions for Learning Science

The learner will be:

- investigating social issues with a scientific perspective (e.g., human rights, wellness, economics, futurism, environmental ethics).
- keeping journals of observations and inferences made over an extended period of time and reflecting upon the impact of these recorded ideas on their thinking and actions.
- examining the intellect, perspectives, and ethics of notable scientists.
- collecting and analyzing observations made over extended periods of time and comparing these to scientific theories.
- creating presentations of scientific understandings using diverse modes of expression.
- conducting formal scientific debates in the classroom.
- formulating processes for determining when questions are appropriate for scientific investigation.
- wondering about the likelihood of events that may occur by chance or coincidence.
- planning and conducting field trips and experiences for small and large groups.

Applications for Science Learning

The learner will be:

- making decisions regarding personal and public health.
- evaluating the social and ecological risks and benefits resulting from the use of various consumer products.
- analyzing the contributions of advances in technology through history to his/her everyday life.
- identifying and reducing risks and threats to a sustainable environment.
- extending the limits of human capabilities using technological enhancements.
- using and recognizing various propaganda techniques.
- solving unique problems using the results of systematic analyses.
- choosing everyday consumer products that utilize recent innovative and pass appropriate performance criteria.
- refining personal career interests through investigations of the diversity of manufacturing, research, service, and invention processes.

Grade Level	Scientific Inquiry	Scientific Knowledge	Conditions for Learning Science	Applications for Science Learning
	The learner will:	**The learner will:**	**The learner will be:**	**The learner will be:**
Grade Ten	explain the influence of perspective (e.g., spatial, temporal, and social) on observation and subsequent interpretations. create multiple representations of the same data using a variety of symbols, descriptive languages, mathematical concepts, and graphic techniques. generate testable hypotheses for observations of complex systems and interactions.	formulate understandings of geologic time (e.g., millennia, periods, epochs). formulate an understanding of the historical development of the model of the universe (e.g., Aristotle, Ptolemy, Copernicus, Brahe, Kepler, Galileo, Newton, Einstein). formulate explanations and representations of the production, transmission, and conservation of energy in biological and physical systems (e.g., weather, volcanism, earthquakes, electricity, magnetism, cellular respiration).	analyzing the historical context which leads to and has lead to scientific theories. seeking information on topics of personal scientific interest from a variety of sources. conducting learner-developed investigations independently and collaboratively over periods of weeks and months. listening attentively and critically to presentations of scientific information made by others. conducting analyses of propaganda related to scientific issues.	predicting and investigating the operation of toys and tools while controlling and manipulating variables (e.g., friction, gravity, forces).

Performance Objectives: Grade Ten

1. Presented with data representing the change over a period of time (e.g., earth spin changes and equinox procession, pendulum motion, stream bed and delta building, thermal cooling and heating, influences on life cycles) the learner will construct a testable hypothesis regarding the nature of the change and conduct an experiment to test it.
2. The learner will identify and discuss structure/function relationships in complex systems (e.g., physiological systems, biotechnological systems, aeronautical systems, energy production and transmission systems, communications systems, transportation systems, waste management systems) with appropriate community and field experts.
3. Provided with data (e.g., linear motion, population fluctuations, solubility, pH, diversity of life over geologic time, inverse square law, rates of reactions) in graphic form, the learner will transform the data into another form that is useful in understanding the phenomenon.
4. Given performance data on several consumer products, the learner will analyze the effectiveness and efficiency of the products and recommend improvements to the manufacturer.
5. The learner will demonstrate skill in the use and interpretation of data from various technologies (e.g., blood pressure apparatus, graphing calculators, high-power microscopy, computer-based interfaced sensors and software, telescopes, weather instruments, satellite telemetry, Vernier scale instruments, oscilloscopes).
6. The student will demonstrate an understanding of the kinetic model of matter by describing its effects on the interactions and transformations in living and nonliving systems (e.g., adiabatic changes, endothermic and exothermic processes and organisms, diffusion and osmosis, changes of phase, water, carbon and nitrogen cycles).
7. Given a set of data on the behavior of mechanical and electromagnetic waves and their interactions with matter (e.g., absorption, transmission, reflection, refraction, diffusion, polarization), the learner will prepare and present an evaluation of the strengths and limitations of the wave and particle models to explain these behaviors and interactions.

Grade Level	Scientific Inquiry	Scientific Knowledge	Conditions for Learning Science	Applications for Science Learning
Grade Eleven	The learner will:	The learner will:	The learner will be:	The learner will be:
	document potentially hazardous conditions and associated risks in selected homes and public areas. participate in public debates, relying on documented and verified data to construct and represent a position on scientific issues. construct and test models of physical, biological, social and geological systems. read, verify, debate and, where necessary, refute research published in popular or technical journals of science (e.g., Discover, Omni, Popular Mechanics). explore discrepant events and develop and test explanations of what was observed. conduct theory-based research using surveys, observational instruments and other methods. modify personal opinions, interpretations, explanations, and conclusions based on new information. analyze error and develop explanations in various domains.	formulate models and hypotheses about patterns in the natural world (e.g., social behavior, molecular structure, energy transformation, entropy, randomness, aging, chaos, hormonal cycles). formulate interpretations of the relationship between energy exchange and the interfaces between components within systems. formulate estimations for the range of energies within and between various phenomena (e.g., thermal, electromagnetic, thermonuclear, chemical, electrical). formulate explanations for the historical development of descriptions of motions, interactions, and transformations of matter and energy (e.g., classical Newtonian mechanics, special and general relativity, chaos). formulate models that can be used to describe fundamental molecular interactions in living and non-living systems (e.g., cell membranes, semiconductors).	performing investigations that require observations over varying periods of time. experiencing scientific concepts as interpreted by other cultures through multimedia and local and global specialists. accessing appropriate technology to perform complicated, time-consuming tasks. relating historical accounts of science to the cultural context in which they were written. working as a contributing member of a collaborative research group. examining the influences of social and political structures and realities that contribute to inquiry about scientific issues. using technology (e.g., desktop publishing, teleconferencing, networking) to communicate scientific ideas. exploring and analyzing a variety of perspectives on science (e.g.,works by men and women of many racial, ethnic, and cultural groups). leading groups of learners of various ages in designing, planning, and conducting science activities.	writing, following, modifying, and extending instructions (e.g., equations, algorithms, formulas, flow diagrams, illustrations). creating products, making inferences, and drawing conclusions using databases, spreadsheets, and other technologies. predicting various scenarios and proposing solutions to community issues using scientific information (e.g., actuarial tables, census data, topographic maps, incidence data, climatic data). using scientific evidence to consider options and formulating positions about the health and safety of others and themself. searching for, using, creating and storing objects and information using various strategies and methods of organization and access. researching and writing environmental impact statements of their own design. comparing school-based science perspectives with those gained through cutting-edge technological applications.

Grade Level	Scientific Inquiry	Scientific Knowledge	Conditions for Learning Science	Applications for Science Learning
Grade Eleven	**The learner will:** formulate taxonomic schemes based upon multivariate models that help to explain similarities and differences in form, distribution, behavior, survival, and origin of objects and organisms. formulate estimations for extremely small increments of time (e.g., milliseconds, microseconds, nanoseconds, picoseconds). formulate interpretations of and hypothesis for further investigation from representations of the same data in a variety of forms (e.g., symbols, descriptive languages, mathematical concepts, graphic formats).	**The learner will:** formulate an understanding of the degree of relationship among organisms and objects based on molecular structure. (e.g., proteins, nucleic acids). formulate hypotheses and models that may account for observable events (e.g., electricity and magnetism, gravitation, atoms, bonding, chemical reactions, quantum effects, energy flow on biological systems, predator-prey relationships). formulate models and hypotheses about change over time (e.g., natural selection, speciation, punctuated equilibrium, phyletic gradualism, stellar evolution, plate tectonics, radioactive decay, quantum mechanical theory).	**The learner will be:** respecting the scientific thinking of others and self. recognizing and contrasting different epistemologies. developing possible courses of action in response to scientific issues of local and global concern. determining the validity of research conclusions in relation to the design, performance, and results.	**The learner will be:** designing management plans for natural and human-altered environments (e.g. woodlots, patios, lots, lawns, farmlands, forests). refining personal career interests.

Performance Objectives: Grade Eleven

1. The learner will collect and interpret data utilizing various sources and techniques on an event or phenomenon that occurs over a period of time (e.g., continental drift, mountain building, weather patterns, radioactive dating, Doppler shift of stellar emissions, structural fatigue in physical systems, population shifts).
2. Given a collection of data (e.g., motion of objects, populations of organisms, observed characteristics of objects and organisms, astronomical data, behavioral patterns, environmental and habitat changes) the learner will propose an organizational structure for a database of the information that is useable by other learners.
3. Given a set of learner-collected data concerning the transformations of matter and energy (e.g., thermoelectric effect, heat pumps and refrigeration, energy and materials transport in cell processes, matter to energy transformation through nuclear radiation, rock cycle, consumer uses of electricity), the learner will construct a model which adequately represents the transformation.
5. The learner will design an investigation of a natural phenomenon (e.g., soil structure, curvilinear motion, competition among living things, reproductive strategies in various organisms) and organize a research team to perform, summarize, and present the results of the investigation to an appropriate audience.
6. Provided with an example of a living area or workplace, the learner will propose practices to minimize potential hazards and risks to inhabitants.
7. The learner will develop an evidence-based position regarding a scientific issue (e.g., genetic engineering, communicable diseases, resource management, funding for cutting-edge technology) and present a persuasive argument in a written or oral format.
8. The student will deomonstrate an understanding of the concept of entropy by applying the concept to describe the effects of interactions and transformations on the structure and function of living and nonliving systems.

Grade Level

Grade Twelve

Scientific Inquiry

The learner will:

- demonstrate various logical connections between related concepts (e.g., entropy, conservation of energy).
- account for discrepancies between theories and observations.
- analyze the changes within a system when inputs, outputs, and interactions are altered.
- create, standardize, and document procedures.
- determine the sources of significant disparities between the predicted and recorded results and change research procedures to minimize disparities.
- research, locate, and propose applications for abstract patterns (e.g., fractals, fibonacci sequences, string theory, orbitals).
- recognize and utilize classification systems for particles, elements, compounds, phenomena, organisms, and others for exploring and predicting properties and behaviors.
- suggest and defend alternative experimental designs and data explanations (e.g., sampling, controls, safeguards).

Scientific Knowledge

The learner will:

- formulate limitations and refinements of standard classification systems (e.g., periodic table, IUPAC, Linnean, standard model).
- formulate specific cases of limitations and possible exceptions of theories and principles regarding the interactions of moving objects and organisms (e.g., fluid flow in vessels, motion near the speed of light, Heisenberg uncertainty principle, meteorological prediction, local variation and diversity, predicting earthquakes, energy transport in cellular respiration).
- formulate plans and contingencies that can be used to accommodate for changes to and stresses on systems (e.g., wildlife and habitat management, corrosion prevention, noise abatement, structure design).
- formulate models of molecular, atomic, ionic, and subatomic structures and the physical and biological implications of these structures (e.g., genes, nucleons, quarks).
- formulate estimates for a wide range of measurements and scales (i.e., angstroms to light years).

Conditions for Learning Science

The learner will be:

- developing multimedia presentations of group and individual research projects and investigations appropriate for a variety of audiences and forums.
- producing interesting and scientifically correct stories and presenting them using various modes of expression.
- reflecting on the ideas and content found in their own journal records.
- examining ambiguous results and formulating explanations.
- recognizing, and synthesizing the contributions to scientific thought of individuals from many cultures.
- constructing models and simulations of the component structures and functions of living and non-living entities.
- leading multi-age groups in the examination of and planned resolution for scientific issues.
- recognizing and choosing members of research teams based upon the merit of their ideas and skills.

Applications for Science Learning

The learner will be:

- promoting public awareness of the interaction of technology with social issues.
- advocating and proposing courses of action for local and global scientific issues using global networks.
- using appropriate technologies to prepare and present the findings of investigations incorporating tables, graphs, diagrams and text.
- making informed consumer choices by evaluating and prioritizing information, evidence, and strategies.
- developing an informed point of view that allows for validation or refutation of the scientific statements and claims of advocates before pursuing courses of action. (e.g., contributing support, signing petitions, casting votes).
- differentiating between observations and inferences in the exploration of evidence related to personal, scientific, and community issues.
- developing and writing environmental impact, and safety and hygiene management plans.

Grade Level	Scientific Inquiry	Scientific Knowledge	Conditions for Learning Science	Applications for Science Learning
Grade Twelve	**The learner will:**	**The learner will:**	**The learner will be:**	**The learner will be:**
	recognize and communicate differences between questions that can be investigated in a scientific way and those that rely on other ways of knowing. draw conclusions based on the relationships among data analysis, experimental design, and possible models and theories. suggest new questions as a result of reflection on and discussions about their own scientific investigations. investigate, assess, and comment on strengths and weakness of the descriptive and predictive powers of science. create new information from representations of data in a variety of forms (e.g., symbols, descriptive languages, graphic formats) utilizing a variety of techniques (e.g., interpolations, extrapolations, linear regressions, central tendencies, correlations).	formulate and interpret representations of time from origin to present accounting for phenomena of scale (e.g., smoothness, punctuations, chaos). formulate interpretations of the historical development of various theories of possible causes of diversity among physical and biological phenomena (e.g., the works of Aristotle, Mendel, Darwin, McClintock). formulate models and hypotheses that can be used to explain the interactions of components within technological, and ecological systems.	constructing a portfolio of products, documentation, and self-evaluations of his/her own abilities, skills, and experiences. synthesizing scientific information from a variety of sources. evaluating and prioritizing scientific issues based upon risk-benefit analyses. refining scientific skills from a variety of experiences.	using technology to collect, analyze and communicate information (e.g., electronic networks, desktop publishing, remote sensing, graphing calculators, satellite telemetry, and others). designing, constructing, and marketing inventions.

Performance Objectives: Grade Twelve

1. Given contradictory observations of a phenomenon (e.g., diversity of plant coloration in a local area, analysis of collision events, micromechanics of corrosion, patterns of ocean tides, energy flows in an electrochemical system, energy relationships in cells) , the learner will present a complete proposal for testing an hypothesis including clear statement of the problem, appropriate hypotheses, complete scientific procedures, data collection methods, analysis protocols and communication plans as a member.
2. Demonstrate understanding of a model of a concept or phenomenon (e.g., micromolecular structure of DNA, speciation, the photoelectric effect, quantum-mechanical model of matter, and energy, genetics and growth, interactions in fault structures, the special and general theory of relativity) by translating between physical, verbal, and mathematical presentations, expressing the essential components of the models, interactions between components, and limitations of the model.
3. The learner will demonstrate the use of a standard classification system to accurately predict properties, interactions, and analyze data (e.g., use the Standard Model to predict allowable interactions and observable properties of fundamental particles, use the IUPAC system to analyze the structure of organic crystals, use the H-R Diagram to analyze the relative age of observed stars, use the periodic table to predict properties and interactions among and between various elements, use a biological classification system to predict the genetic correlation between groups of organisms, use EM spectra to predict levels of hazard associated with exposure to various EM regions over time).
4. The learner will construct and present a summary of human impacts on the environment when provided with data collected from the area.
5. The learner will implement a plan for the management of a system over a period of one month or more (e.g., a solar powered structure, a marine aquarium, a robot,his/her body, an automobile, a compost system, a swimming pool) that is based upon learner-collected information and data.
6. The learner will relate the impact of historical scientific discoveries to the issues confronting contemporary society (e.g., vaccinations, plastics, xerography, polarizing filters, military technologies, nuclear energy, earthquakes. anesthesia, antiseptics) using a persuasive presentation of a fully-developed position.
7. The learner will demonstrate an understanding of the overarching organization in the universe (e.g., relativity, entropy, chaos, grand unification theories) by applying an organizer to describe interactions and transformations in living and nonliving systems.

Scope and Sequence Considerations

Selection of the grade level units that make up the science program should be based on several priorities including: (1) materials; (2) resources available; (3) developmental appropriateness; and (4) preparation of the teachers charged with the instruction at that level. In the middle grades, it has been common to separate the content into life, earth/space, and physical sciences while in other cases the content is organized with all three domains of content in each grade of the middle years. Recommendations from the National Science Teachers Association and the National Middle School Association stress the reorganization of traditional, domain-centered science courses into integrated, thematic programs.

The essence of the decision to be made is the choice of subject matter that is relevant, engaging, and developmentally appropriate for the learners. The content chosen should address each of the organizing concepts previously identified in the science curriculum (see Developing a School Science Program) and the priorities listed above. It is vital that middle level learners develop a strong conceptual understanding of science before beginning quantitative studies in the sciences in high school.

This Model proposes four possibilities for high school studies in the sciences with a brief explanation for each. There are dozens of ways to develop content within the priorities listed above. The first three possibilities given here should not be considered to be the most innovative possibilities available, nor do they support a traditional view of high school science courses. There is no importance implied in the order of their presentation. Instead, they are designed to help schools find and sort out ideas that will begin the transition from fact-based science to a science program designed to produce scientifically literate and technically skilled students. In all cases, all courses should provide significant amounts of engaging and significantly challenging opportunities for all learners to inquire about the natural world. Critical to the continuation of the scope and sequence into the high school years is the level of preparation of the teachers involved and a firm grounding in the major concepts of science constructed by each learner in the earlier grades. A strong conceptual foundation in the three science domains that has been incrementally constructed by all students in their pre-K through grade 8 science program is the foundation for the success of all possible high school programs.

POSSIBILITY ONE: In this plan, students have the freedom to select from a variety of content perspectives. In each case, learners are expected to develop scientific literacy and a high level of technical skill. Any given offering would include students from various ages. Once again, it is critical that all students have a strong, conceptual base from the earlier grades and that the teachers are well prepared to work with the learners in these areas. Additionally, designers should work to ensure that material is covered in depth and connected to all three domains of scientific knowledge, STS (science, technology, and society) concerns, and de-emphasize redundancy. The length, complexity, and sophistication of these offerings may vary.

Grades Nine to Twelve (no order is implied for these content examples)

Aeronautics
Agricultural Science
Anatomy and Physiology
Astronomy
Biochemistry
Biological Science
Biotechnology
Botany
Chemistry
Earth Systems Science
Ecology
Environmental Science
Physics
Zoology

All of the offerings in this plan are for all students at higher grade levels. Thus this arrangement supports the educational philosophy that students of all ability levels and students of varied age levels can successfully learn side-by-side. This possibility, as well as the other two, requires professional development to provide teachers with opportunities to learn pedagogical strategies to help learners to be successful.

POSSIBILITY TWO: In this plan, the three domains of science are presented at each grade level (similar to the approaches advocated by the NSTA's Scope, Sequence, and Coordination project). This plan is often referred to as a coordinated science approach. In each offering, the level of sophistication increases although it is mostly quantitative in nature. This plan may look like:

Grade Nine – Coordinated Science I

Grade Ten – Coordinated Science II

Grade Eleven – Coordinated Science III

Grade Twelve – Coordinated Science IV

POSSIBILITY THREE: In this possibility, relevant and engaging science is presented in order to sequence courses from foundational sciences to sciences that are more applied. Prerequisite to this approach is a firm grounding in the study of mathematics for all students. Each of the offerings is designed to be connected to the other three and should contain a greater level of rigorous, quantitative content than is found in the middle years.

Grade Nine – Physics (Investigation of the big ideas foundational to and applied in all of the natural sciences).

Grade Ten – Chemistry (Investigation of the physical components of the universe and their interactions and transformations).

Grade Eleven – Biology (Investigation of the application of physics and chemistry in living systems as they exist in the physical setting).

Grade Twelve – Earth and Space Science (Investigation of the application of physics and chemistry in non-living systems as they interact in living systems).

POSSIBILITY FOUR: Local district design based upon local needs and expertise consistent with the spirit and intent of Ohio's Model Competency-Based Science Program.

ASSESSMENT AND INTERVENTION SERVICES

Any intervention activity designed to remediate, reinforce, enrich, and support student learning relative to the specified performance objectives will frequently be necessary. Intervention services must be available to every student. Two very important assumptions need to be considered:

- intervention must always be tied to curriculum-embedded assessment, and
- intervention is a responsibility shared by learners, educators, and parents.

These assumptions undergird any successful intervention program. The tie between intervention and assessment seems obvious. To plan and implement intervention procedures or strategies without assessment information on student performance would be illogical. The relationship between these two important concepts, however, is neither direct nor simple. A competency-based program developed by individuals who understand human learning, curriculum development, and science will include intervention and assessment components which are interrelated, which build upon each other, and which are not necessarily sequential. It is important to remember that assessment may be formal or informal, but the assessment results should always indicate to the teacher the type of intervention needed. This means that a single assessment is inadequate to indicate the need for and/or kind of intervention that should be provided. Intervention programs need to be based on the full-range of curriculum-embedded assessments that are included in a district's competency-based education program.

Intervention is a responsibility to be shared by educators, parents, students and members of the community. In the broadest sense, intervention is the responsibility of all individuals who care about student achievement. Minimally, intervention should be structured through classroom, building, and district levels, and at home. Ideally, these structures would involve students, teachers, parents, and building and district administrators. When a student's need for intervention cannot be satisfactorily addressed by the regular classroom teacher, it will be necessary to have building and district options available. Building-level options might include interclass grouping, intervention assistance teams, tutorial programs, and resource/intervention rooms and teachers. District-level options might include summer school programs, in-term extra hours programs, and required academic courses and voluntary enrichment programs. Provisions for intervention services, including adequate resources and appropriate staff development, should be made at all levels.

Classroom-Level Intervention

The primary responsibility for providing intervention rests with the classroom teacher. The teacher must be able to identify the need for intervention, design the instructional form it will take, and implement the action. This requires a great deal of skill in classroom support, reinforcement, and enrichment techniques. The teacher must have the capacity to utilize instructional materials, have expertise in teaching for different learning styles, and group students for special needs. The ability to understand and use various assessment tools, analyze assessment results, and teach prescriptively are critical elements of effective intervention. A teacher who is astute, creative, and knowledgeable in the areas of science and pedagogy is the key to an intervention program which meets the needs of students. While the local curriculum and lesson plans focus upon group outcomes, intervention must focus upon the individual student. Intervention in the classroom can take place during a lesson, after a lesson, at the end of a unit, or at other times depending upon the results of assessments all through the process. Any or all of these models accommodate one-to-one teacher-student interaction, as well as various tutoring models.

There are many paradigms for instruction/intervention at the classroom level. Three of the most commonly observed patterns (though not necessarily the most educationally sound) are characterized by (1) whole-group instruction followed by attention to individual needs; (2) whole-group instruction followed by collaborative groups; and (3) group problem-solving strategies. These three patterns represent some of the most typical classroom teaching models. One-to-one teacher-student interaction, tutoring situations other than those involving classroom teachers, and situations where students discover and explore individually on computers represent just a few of the many other instructional models that are not as readily observable.

An exemplary "whole-group lesson" is designed to cause students to think about the ideas that were presented, stimulate internalization of those concepts, and elicit feedback as to how well the new concepts or techniques are being understood. Good whole-group instruction models many of the components of effective communication. It is important that instruction be viewed as interactive among teachers and students. Students must not view themselves as receptacles to be filled by the teacher, and teachers must not see themselves as founts of knowledge whose only responsibility is to spew forth that knowledge in clear and motivating lessons. Understanding comes through activity and dialogue. Students have a major responsibility for learning in any instructional setting, including large-group lectures. Even so, learners respond at various rates and with varying levels of understanding. Individual student responses will provide teachers with opportunities to extend, amplify, or "back-up" student understanding. Student responses should allow able teachers the opportunity to identify those students who need more time to fully grasp the concept and opportunities to extend their learning. Teachers must possess a repertoire of teaching skills and strategies that can be brought to bear during intervention episodes. This repertoire should include listening and questioning skills, knowledge of and facility with alternative processes, and an ability to present concepts and ideas in formats that will address learners possessing various learning-style strengths and motivational levels. As instruction continues, the teacher has ample opportunity to elicit both formal and informal feedback from students.

At some point in this process, the teacher must decide how many (as well as which) of the learners understand the lesson ideas well enough to go on to independent work. It is important that teachers assume the role of diagnostician in order to determine the need for enrichment, reinforcement, and remediation for individual students.

Since most teachers routinely use what they consider their "best" or "most-effective" teaching strategy, they are sometimes hard put to come up with effective intervention strategies. Yet development of several alternative strategies is an important part of professional growth, and it is essential in meeting the intervention needs of students.

At the core of classroom intervention is effective instruction that zeros in on individual student needs. Teachers who view themselves as facilitators of learning enable students to access scientific knowledge. In general, instruction should be focused as much upon the process of learning as upon what is learned.

Building-Level Intervention

When the intervention possibilities provided in the classroom are not sufficient to meet the need of an individual student, it is sometimes necessary to provide other instructional alternatives to support and enrich learning. These would include interclass grouping, the establishment of a resource room, and mentoring programs that can be established at the building level.

Interclass grouping is most appropriate when groups are formed for short periods of time with highly fluid structures and membership. Since intervention is best handled at the classroom level, this alternative should be used only after the classroom teacher has decided that the options for intervention within the classroom cannot meet the needs of the students. These groups can also be formed around interclass group members who wish to extend learning on particular topics.

The establishment of resource rooms is also an alternative which may be valuable to meet student needs. These centers may be places where students can receive valuable one-on-one attention or participate in group investigations. It is absolutely essential that the person or persons staffing centers such as this be knowledgeable about content, methods, and materials necessary for the development of support and enrichment programs, and in addition, be able to implement such programs.

Mentoring programs offer proven and practical ways to help students. Mentoring programs offer ways for students to get much needed personal attention. Again, it is important that all persons acting as mentors, whether they be volunteers, other students, or classroom teachers, receive specialized preparation in terms of methods and content appropriate for students.

District-Level Intervention

Students who need or desire additional support and enrichment as well as participating in classroom- and building-level intervention programs provide impetus for the creation of district programs. These might include highly individualized summer school programs, before- or after-school programs during the regular school year, and postsecondary enrollment options. These represent the some of the more costly intervention programs, and it is important that true "alternative" instruction be given. These efforts should rely heavily on the use of learner centered activities regardless of the grade level or age of the student. All students should receive instruction in problem-solving techniques and methods of applying known scientific ideas in a variety of situations. It should be noted that for this and all other intervention programs and practices, extensive practice in memorizing scientific information is usually counterproductive. It takes time away from appropriate concept development through problem solving.

Two thoughtful examples of intervention in science follow. These examples reflect possible intervention practices. Meeting the needs of an increasingly diverse student population while society's need for a well-educated citizenry continues to escalate, presents educators with new challenges and opportunities. The intervention services and strategies should be considered in light of their appropriateness for situation, content, and student. Teachers have the ability to adapt general ideas and suggestions to specific situations. This talent is nowhere more important than in the selection and implementation of intervention strategies. What follows are examples of intervention episodes. In each episode, the intervention is tied to classroom-based assessments. Both of the examples illustrate the thought process in which a teacher might engage when making intervention decisions.

An Intervention Episode – Enrichment

Often educators unintentionally equate intervention with remediation. In order to help dispel that notion, this intervention example will illustrate how an intervention episode may be designed that provides one or more learners with enrichment activities based on observations and other assessments of an in-progress learning activity. At the same time this intervention example will suggest some activities that will address ways to reach instructional objectives that are less often emphasized.

As a part of an environmentally oriented unit Mr. Wolf, along with his multi-aged learners, has planned and carried out a water quality monitoring project on a nearby stream and an associated standing body of water. Because of the age range and multiple ability levels represented in the group, a diversity of water monitoring (and related) activities has been included. Some of the activities were carried out by individuals while others were group tasks. Some were suggested by the learners while others were suggested by the teacher. Some of the activities were:

1. Using the presence and quantity (or absence) of water habitat organisms and comparing this collected data with established norms, learners were able to make rough estimates of water quality.

2. Using simple equipment and sense extending devices (e.g. secchi disk, microscopes, graduated porosity paper filters or screens, centrifuge) learners were able to: (1) separate and identify some suspended solids; (2) determine clarity (turbidity); (3) identify organisms; (4) describe color and smell; and (5) comment on the aesthetic or physical impact of the body of water.

3. Using standard testing procedures for various parameters (e.g., pH, phosphorus, other minerals, dissolved oxygen, pathogens, and others)learners were able to collect data that were compared with results fromother learner groups within the school and with state or federal standards.

As self-chosen small groups worked on these learning activities the dialogue among group members produced significant gains in cooperative learning skills and the learners were able to recognize and discuss these improvements and often devised strategies to improve upon weak skills. Further, they were able to make self-evaluations in terms of the learning skill goals they had chosen to reach.

Since these activities occurred over a four week time frame, often discussions occurred between members of different task groups. These dialogues were associated not only with the level of sophistication of the water quality monitoring techniques but with an array of other important aspects of learning, e.g., tenacity, creativity, accuracy, data interpretation skills, locating information sources, pondering and framing new questions to pursue, divergent thinking, and others.

As the four week project proceeded Mr. Wolf took note of the triumphs and frustrations, the skills and attitudes, and the growing initiative and independence of the learners. He did not allow learner frustrations to turn into disinterest. He encouraged the able learners to add to their goals and strike out on new intriguing tangents while retaining their responsibility to the other group members to finish the group task.

Mr. Wolf was well aware of the six year age range of the learners, the wide range of experience and multiple abilities (intelligences) they had, and the varied personal attributes they possessed. He skillfully and appropriately intervened with individuals or with task groups with these suggestions:

1. When Jane related that her grandparents had become ill from some waterborne contamination, she was encouraged to (1) do some drinking water quality testing, (2) find out who is responsible for ensuring

drinking water quality, (3) contact a school near the grandparents home to see if there is useable information available, (4) conduct research on waterborne diseases, and (5) help Jane's grandparents identify and correct the contamination problem.

2. When task group one was working on the water habitat organisms project, it was clear that Jim was far ahead of the other group members in his understanding of this water quality testing technique. Jim needed to learn how to assist his peers with this project without spouting off about all he knew. He was encouraged to derive satisfaction from the other learners' successes, while at the same time, invent, individually, a more sophisticated or more accurate organism indicator test. Nancy showed an interest in the anatomical structures of the organisms and so Mr. Wolf encouraged her to find library resources about her interest and to contact a marine biologist at the local college. Carlos needed to build his self-esteem because English was his second language and his natural abilities were not always evident to his peers. Using his artistic and special talents he illustrated the group's final report.
3. When task group two was measuring turbidity with a secchi disk, Mahalia became fascinated with the measurement of clarity. Mahalia had previously shown her spatial, bodily-kinesthetic intelligences by designing and constructing testing apparatuses and needed encouragement to create a more accurate clarity test by using a light source to shine light through water of varying distances, determine initial andfinal intensity of the light, and design a numerical scale for use withvaried water samples.

The above intervention activities suggested by Mr. Wolf are only a few of dozens that could be used to enrich a learning episode for able learners or that would help learners grow in some critically important areas, e.g., self esteem, initiative, independent functioning, tenacity, divergent thinking, designing and planning experiments, and many other instructional objectives that are contained in the district science course of study. It is incumbent on the leader of the learners, therefore, to recognize learner strengths of many kinds and be able to suggest courses of action that will result in new challenges. As both leaders and learners become familiar with a more flexible and open-ended learning environment, the learners will blossom and will often astound their parents, peers, and teachers with their ability to handle advanced learning.

An Intervention Episode – Remediation

Objective under consideration:

> Given a question about a natural phenomenon, the learner will propose several sources of information that may assist in addressing questions about the phenomenon. (fifth grade)

The assessment for this objective:

The water cycle diagram below portrays a complex scientific idea. It includes names of component parts, names of specific processes involved, and pictorial representations of how these parts and processes are interrelated. Neither the text nor the diagram fully explain all that might be explained. If you wanted to find out more detail about the water cycle, write a question and suggest several sources you might use to find additional information.

Student responses:

Beth: Is water vapor always invisible?

1. encyclopedia
2. chemistry textbook
3. an article in a science magazine

Mark: How are snow and ice part of the water cycle?

1. an article about Admiral Byrd

2. meteorology references

3. the meteorologist on the TV news

Ginny: How can you determine how fast water will soak into the ground and how does it turn into ground water?

1. look under groundwater on my computer encyclopedia

2. ask a farmer

3. ask a librarian for help

Although Mrs. Patton, the fifth grade teacher, has been striving to broaden the learners' ability to use a divergent array of sources to find information, these three students are relying on the same few resources. Further, they are still not fully adept at pinpointing the best or most reliable resource. It is clear that some further activity (intervention) is needed.

Intervention strategies:

Mrs. Patton meets with Beth, Mark, and Ginny individually and reviews the objectives that they are working on and refreshes their memory on the recent classroom activities that involved this objective. He asks Beth to go to the library and look up and read about: gases, water, water vapor, and vapor and write down relevant information about her question. Mark, who also needs experience talking with adults, is directed to ask four adults what sources of information they might use and then choose four that are suggested that are new to him and use them to try to answer his question. Ginny's three responses, although legitimate, show a consistent "easy way out" flavor. Mrs. Patton decides to send Ginny to a female soil scientist who works for the county soil and water conservation district. The two of them will work together to expand Ginny's list of sources and work toward being more specific in the location of information. Through this experience, Ginny will begin to appreciate and accept the realization that finding the sources that can help her to find some answers often is the most satisfying part of science.

When each learner has completed the assignments, all four will meet together and discuss how each of them has improved on reaching the objective. Mrs. Patton will monitor Beth, Mark, and Ginny as they identify and use information sources in future learning activities.

This intervention episode is intended to illustrate the various levels of analysis necessary to make sound diagnoses about student learning and the kinds of prescriptive instructional responses selected and/or developed to address the specific needs of students. The relationship between assessment (collecting data and information to make decisions about student achievement) and intervention (the range of alternative instructional behaviors designed to redress specific learning challenges) must always be maintained. The work is difficult, the challenge enormous, and the reward priceless. This is the very best of what teaching is about.

APPENDIX A
LEARNING EPISODES

At any particular stage of educational reform, the dialogue surrounding learning episodes continues to be influenced by many factors and constituencies, such as current learning theory, research-based pedagogical approaches, utilization of educational technologies, and trends and issues surrounding world-class standards for science education. No one combination of learning episodes, utilizing many different teaching-learning strategies, can be said to be the ideal for a given situation. Student capacity, teacher capacity, learning environment, curriculum materials, equipment, stated goals, and more, all impinge on the development of quality learning episodes. There is, however, growing evidence that the characteristics of learning episodes can be placed on continuums and that movement along those continuums should be expected of teachers and learners.

Therefore, newly constructed learning episodes should clearly facilitate these movements. Emphases suggested here should assist educators in reflecting how a particular learning episode contributes to change in one or several characteristics. In general, characteristics should emphasize:

- cooperation
- learning by doing
- individual and cooperative performances
- learner self evaluation
- individual responsibility
- learner participation in decision-making

The selection of learning episodes included here is meant to be representative of the many locations along many continuums. As local science goals and outcomes are written, learning episodes will have to be chosen or created that are best suited for the learner to acquire the desired characteristics or skills. These episodes may be one hour, one week, or any duration as determined by teacher and students.

Learning episodes (units, lessons, events) of wide diversity have been cooperatively planned by teachers and learners, by teaching teams, or by individual teachers. Additionally, national or state curriculum projects have sometimes written excellent episodes. Textbook authors too, have suggested learning activity sequences that have been successful. Any group of educators and interested persons who are designing learning episodes can make significant contributions to improving elementary and secondary education by searching the current literature for quality examples or creating original episodes.

This document stresses the integrative nature of learning. Integrative learning, sometimes called transdisciplinary, or topic-based learning, is gaining in popularity and is receiving high praise for its effectiveness. Each school or district will need to determine how quickly, how efficiently, and how completely these integrated learning episodes can be implemented.

There is not space here for an extensive listing of the characteristics of quality learning episodes but this short list will help you start a challenging and rewarding process.

- cooperatively planned by leaders and learners
- developmentally appropriate
- emphasizes learner goal-setting and evaluation
- emphasizes skill development and concept acquisition
- intentionally transdisciplinary

Additional articles and books that elaborate on the characteristics of good teaching and learning can be found in the bibliography.

The learning episodes that follow are only suggestions designed to start your process. You are sure to find many others. Those that have been taken from another source have been so designated. Others may have been written by Ohio science educators or by the Departmental writing team.

Learning Episode One

Making Bread

This primary episode is based on seven instructional objectives taken from strands two and three. A curriculum committee or a teacher might well choose a different selection of subject objectives from the four strands for emphasis in this particular activity. The critical idea is for the teacher and the learner to overtly carry out a dialog as to the objectives that are the foundation for the activity and consciously cooperate to reach them.

Selected Subject Objectives from Strands

- explore how things change when different ingredients are mixed together. (Mixtures solutions, colloidal suspensions)
- explore mathematical expressions of quantities
- share ideas while observing events and manipulatingmaterial
- manipulate various contain ers to discover and compare capacities
- follow simple directions
- contribute to the work of groups
- experience in describing food in sensory terms

Components of the Bread Making Activity

- gather ingredients
- measure ingredients
- follow directions
- asking "why" questions
- watch the ingredients change as mixing proceeds
- "wonder" about the purpose of each ingredient
- watch the bread bake and wondering what's happening
- taste, smell, and feel the bread
- review the experience and wonder what would happen "if" the proportion of ingredients was changed
- read about bread (history, culturally diverse uses)
- write about bread
- develop a group report about bread

Learning Episode Two

An Integrated Curriculum Unit – Seeds

"How do seeds live? Can seeds grow way, way, deep in the ocean and make seaweed?" "How do seeds get inside watermelons?" Hey! How do they make watermelons without seeds in them? How do seeds grow into plants?" These are some of the questions asked by Ms. Lopez's second graders.

Today seeds are the topic. As the students are thinking about the origin of seeds, Ms. Lopez writes down their questions on a piece of oak-tag titled: "Questions We Have About Seeds." Another chart entitled "What We Know About Seeds" contains such statements as "Seeds grow in gardens," "You can eat sunflower seeds," and "You don't eat seeds." Ms. Lopez refers to these charts constantly. She encourages the children to ask questions, and she guides the children as they form their concepts and change their beliefs. She uses their questions and comments to decide whether the children are ready for a "seed walk."

The next morning all the students go to a nearby field and collect seeds. Each student, besides carrying a collection bag, wears a large wool sock over one shoe and pulled up to the knee. It is used for collecting seeds. After returning from the walk, each student selects one seed to study carefully with a hand lens. They observe what the seed looks, feels, and smells like, and they guess how it might travel. Then each child makes a presentation to the class, which is gathered in a meeting circle. By taping the seed specimens onto a chart, the teacher keeps track of the different seeds the class discusses. After the students tally how many of each seed they found, they graph their results.

That evening after the seed walk, Ms. Lopez reflects on the differences in the children's understanding of the structure and function of seeds. She notes which children easily made observations and which ones had difficulty, which children made more obvious or more creative responses, and which children seemed comfortable or uncomfortable using the lens for examining their seeds. While planning the next day's activities, Ms. Lopez consults her notes and places the children in groups that will prompt and challenge each student.

The next day, some groups choose to count seeds that came back on their socks and then plant the seeds in large, self-sealing plastic bags containing cotton and water; the groups then place the plastic bags near the windows. In the days that follow, the groups will observe the germination process carefully and compare the total number of seeds with the number that sprouted by making "ratio" graphs and by writing corresponding sentences. Ms. Lopez invites other children to compare sizes of seeds; she asks them to outline the seeds on graph paper and then count the number of graph squares that each seed covers. The students discover that there is a great diversity of sizes and shapes in different seeds and that the same kind of seed varies in size and shape.

Still other groups choose to continue working on their "seed journals" that Ms. Lopez requires all the students to keep. The children either paste in or draw the specimen and then write about three seeds of their choice, including observations shared earlier in the meeting circle. Because these second grade students have a range of writing capabilities, Ms. Lopez meets with each child and discusses that individual's observations and writing. She uses both the journal entries and group presentations to monitor their understanding of concepts.

In subsequent lessons, Ms. Lopez brings in an example of a common seed, popcorn. While the children enjoy popping and eating the popcorn, Ms. Lopez reads to them from the book Popcorn by Tomie de Paola. The children are surprised to learn that popcorn has a very long history, and that Milwaukee and Minneapolis are the top popcorn-eating cities. They talk about how the Native Americans used popcorn for food and jewelry.

Afterwards students make a timeline depicting the various groups that were known to have used popcorn. In centers located around the room, some groups help each other to make jewelry by making strings of popcorn and others paste seeds on sheets of paper to make art patterns. As the unit extends to the study of Colonial Americans and their crops, and then into farms and farm communities, students make a "crop" collage of fruit and vegetable pictures taken from magazines. They enjoy composing a song about crops called "Old MacDonald Has A Garden." The students complete additional reading, writing, and mathematical assignments.

During lessons, Ms. Lopez calls groups together and asks several activity-related questions, the answers to which should be based on students' explorations. As she records the students' responses, Ms. Lopez asks the children to clarify their answers. Eventually she introduces new vocabulary words and information; they need more time for discussion and additional exploration of ideas before the new information becomes a part of their personal understanding.

After her students have studied seeds for several weeks, Ms. Lopez recognizes that they have learned a great deal about diversity, life cycles, the structure and function of seeds, the role seeds have played in history, and their importance to communities as food and crops. The children have become adept observers; they have learned to ask each other and Ms. Lopez about these developing concepts. Ms. Lopez knows they will be ready to apply their knowledge and skills to other areas. With her class, she will return to the original questions and the children's answers for them. She will point out how much they have learned. The children will, as a group, write and produce a booklet on how to plant seeds and care for the seedlings. Ms. Lopez will keep notes on the progress of each child and the class as a whole. Her notes will then become source materials that will enable her to make more formal assessments for report cards, conduct meaningful conferences with parents, and provide whole–class information to Mr. Sandowski, the third grade teacher.

Source: Reprinted and modified with permission. Curriculum and Instruction, The National Center for Improving Science Education. Washington, D.C. 1989, pp. 1-2.

Learning Episode Three

Water, Water Everywhere

Any learning episode could be carried out with literally hundreds of purposes in mind. In fact, this characteristic of the teaching-learning process is what makes the teaching profession the most complex, challenging, and rewarding of any found on the face of the earth. This episode should be helpful in further illuminating the educational reforms that are leading us into the Twenty-first Century.

It must be remembered that over the thirteen or fourteen year span encompassed by elementary and secondary education, hundreds and hundreds of learning episodes will take place and opportunities for learners to develop learning skills, habits of mind, dispositions, confidences, and knowledge will be counted in the thousands in order, to make this learning episode of manageable length. Only a carefully selected number of considerations will be mentioned. As individual teachers, teacher teams, or learner-teacher coalitions go though the episode planning process, more, less, or different considerations will be selected depending on the learners' developmental levels, interests, and abilities.

The left hand column will contain words, phrases, or subject objectives taken from the four strands that suggest the basis for the actions that are described in the right hand column. They will need to be selected, consciously pursued, and openly revealed to all the learners so that leaders and learners together can see the road ahead and be simultaneous contributors to reaching the stated targets. Since there are emerging major shifts in the way education all levels is pursued, it will be helpful to keep a few basic premises in mind.

- a great deal more of the responsibility for goal setting, planning, learning, reflecting, and evaluating will reside in the learners
- an increased portion of learner effort will be devoted to a personal pursuit of excellence rather than the here-to-fore win-lose competition with peers
- effective collaboration and cooperation with others of varying abilities, cultural diversity, personality traits, age, motivation, self-confidence, and other traits will be the predominate mode of learning
- learning in a school setting should be much closer to real life with opportunities for enjoyment, laughter, hard work, and vigorous play while at the same time paying attention to the optimum development of a love for beauty, tolerance, civility, honesty, and care giving.

You are encouraged to develop your own list of basic premises upon which you build your array of learning episodes.

So, let's begin! Remember that this episode is not grade specific so you will find purposes and subject objectives from all four strands and a wide span of grade levels.

The Purposes for Action	**Description of Leader-Learner Activity**
Planning the episode	
• learner involvement	• conduct a preliminary meeting with the planning team (teacher, teacher team, teacher-learner team)
• developing confidence	• think about hyping the episode; processes to be used; goals to be pursued; length of time; diversity of people to be involved

• cooperative goal setting	• emphasize the fluidity (openness) of the episode (adjustments and new conditions will emerge as the process unfolds)
• risk taking	
• creativity	

Initial session with all learners

• maximum participation	• conduct a brainstorming session with the whole class so that the "technique" can be demonstrated and refined
• non threatening environment	
• all contributions genuinely accepted by leaders and learners	• an alternate procedure would be to have one, two, or three learners at the blackboard or a 20 foot long "wrapping paper" writing place to record the brainstorm ideas
• skills: divergent thinking; classification	• as topics and activities for the water episode are contributed by the learners (the teacher(s) should judiciously suggest items too) each learner should be asked where it should be added to the recording surface. In other words, as items are added, the contributor should make a judgment as to the similarly or difference of his/her item to those already suggested. This allows the learners to begin to think up new items that are consistent with their experience and ability in brainstorming and categorization. More creative or higher ability students can derive satisfaction from suggesting different items whereas less experienced or lower ability learners will derive satisfaction from suggesting items that are very similar to ones already on the board. • after one or two sessions there should be a wide variety of ideas in the form of questions or statements of fact or just phrases suggesting opportunities for investigation. Note: The length and number of the sessions depend on such factors as learner age, previous brainstorming skill development, and ability.

Small group refinement

• small group discussion skill development	• form groups of four or five to further refine the master list
• refinement of categorization skills	• encourage clarification of the items • move items to other categories depending on discussion
• tolerance of personality diversity	• expand or reword items
• every learner a contributor	• determine new categories or titles for them • complete a revised list

- have each small group share with the other groups their revised list in written form

Note: If learners have not had opportunities to learn how to set their own goals some judicious guidance will be needed.

Individual or small group interest selection

• learner goal setting (realistic yet challenging)	• allow both individual and small group interest selection
• participating in the choice of learning activities	• this could be done informally over a few days to allow learners to begin to find others with similar interest or discover that one of their interests is unique.

Individual and small group planning

• planning & sequencing	• allow time to develop plan of action: refining activities, problems, or investigations
• decide on responsibilities	• be aware of group decision making
• set tentative time lines	• allow for individual interests
	• write final plan

Individual and small group activity

• seek information in several different places • invent, describe and carry out simple cause and effect investigations	• over a period of time encourage small groups or sometimes individuals to engage in: (1) informational searches; (2) designing and carrying out appropriately complex investigations;(3) designing unique ways to communicate ideas and concepts to others; (4) making connections between or among seemingly disparate concepts; and other learning pursuits
• speculate on commonly held assumptions about phenomena in their world	• gently but firmly convey to the learners that they are responsible for their learning, for obtaining information, for assembling needed materials, working out glitches in the process or plan, and evaluating their own or their group's work
• choose appropriately accurate measuring devices	
• take time to coherently discuss or explain outcomes of observations and investigations in terms of how they conflict, support or extend their previous understandings • explore the impact of light and heat on water	• the brainstorming session should have produced enough activities to last the whole year so the learners (and with gentle advice from the leader) should choose one or more activities they would like to pursue in the time available. Often the pursuit of one activity will cause a spin-off activity that will be pursued with great enthusiasm. The learning should be as open-ended as possible with flexibility as great as is comfortable for learners and leader.
• explore different ways of stating who, what, where, why, when questions	• The following list of learning activities are a sample of those that might have been generated by the learners with minimal input from the teacher. It is important that you use the learner

- discover patterns
- explore the relative contributions of the components in a system
- explore the significance of historical events related to their activity
- investigate the chemical and physical properties of water
- manipulating various containers to discover and compare capacities
- identifying community issues and generate courses of action
- taking a variety of roles in group work
- recording observations using a variety of technologies
- taking time to redesign and repeat investigations
- discussing, researching, and writing about current water events
- listening to, reflecting upon, and interacting with ideas and expressions of others
- maintaining journals of observations and inferences

generated list and resist the temptation to give them this one. This list is not grade specific but is suggestive of a wide range of activities for multi-aged groups, high ability learners, or mixed ability learners

- determining the factors that control the rate ice melts
- determining and evaluating the taste of different waters
- measuring water volume, flow temperature
- discovering the many different sources of water
- finding out why water is called the universal solvent
- learning about the three states of water and the processes and conditions of the transformations
- water as a beneficial and destructive force
- supply, demand, use, and conservation of water
- the physical properties of water
- scientific discoveries about water
- role of water in the various cultures of the world
- role of water in biological systems
- sports and water
- uses of water in production art
- meditative, spiritual, aesthetic, and recreational uses of water
- the cost of water in selected places or as an ingredient in products
- the poetry, prose, and art of water
- water as a habitat

Note: As you can see a brainstorming session may result in a very long list of possible investigations or activities.

Conclusion, communication and evaluation

- analyzing and resolving con- and debates that occur during learning activities
- using appropriate terminology to report investigations of science concepts
- using a variety of modes of community expression to communicate ideas
- maintaining group records

- summarize, analyze, organize and otherwise bring activity flicts to closure
- evaluate the processes involved in the activity- individually and collectively
- evaluate the activity according to the initial or revised goals
- determine the format for communicating the concluded activity to a leader, parent, peers, group, or others
- list the content and process learning that accrued
- reflect on such ideas as confidence, self-esteem, risk-taking, tenacity, patience, assertiveness and others

This learning episode may be used as an interdisciplinary science unit which includes life, earth, space, and physical science concepts. Yet, it is obvious that in the diverse activities suggested it can easily be used as a theme-based unit (transdisciplinary) that includes the exploration of concepts from disciplines outside of science. But, even more importantly, the episode makes it possible to work on the general goals of education in the five science education goals. This holistic, multiple-dimensioned learning is the wave of the future and we all need to embrace it.

Helping learners learn in this way may well be a demanding experience for many leaders of learners. No matter how far along you are toward transformational teaching and learning, this episode will reinforce your desire to move confidently forward.

APPENDIX B

SCIENCE MATERIALS AND EQUIPMENT

This Model defines instructional materials as print and non print materials, equipment, technology, and commercially-available curriculum projects and programs such as those supported by the National Science Foundation and the U.S. Department of Education. For more information regarding National Science Foundation science education projects, write to the National Science Foundation or the Eisenhower Clearinghouse as listed in Appendix D.

There are commercially-available instructional materials which cost no more than textbooks, some much less, that support the spirit and intent of the Model.

> *...current and forthcoming National Science Foundation material development projects at the elementary and middle school level reflect the spirit and substance of the call for reform. Several features differentiate these projects from [many] current programs and practices, for example:*
>
> *a. conceptual schemes serve as content organizers;*
>
> *b. technology, both as content and tool, is an innovation characterizing the reform;*
>
> *c. fewer concepts are studied in greater depth; and*
>
> *d. content ant teaching methods are based on assumptions about children's learning.*
> Shymansky, J.A. & Kyle, W.C. (1992)

The vigorous acquisition of equipment and material resources is crucial to a quality program. Out of pocket spending by teachers, purchases funded by bake sales and parent teacher groups, or the use of excessive lab fees for basic consumables and equipment should not be thought of as adequate.

As scientific and technological equipment becomes more sophisticated in the general culture so must it become so in the science education program. A triple beam balance and its limited accuracy and efficiency must give way to an electronic balance. Sweep second hand timing devices need to give way to electric, laser, or light activated timers. Sensing equipment of all types must also provide appropriate accuracy as for example being able to detect minute amounts of substances perhaps as small as one part per million or even billion.

As a preorganizing set of criteria, instructional materials selection should be based on the use of these materials to expand and enhance the opportunity to learn by

- Matching materials with the developmental readiness of the learners;
- Reducing risks, to safety and health, inherent to scientific activity; and
- Increasing the quantity and quality of the hands-on experiences.

Equally important to equipment acquisition is its maintenance and easy accessibility. Teachers and learners need to learn to use and care for a wide variety of scientific equipment and technologies. Materials need to be readily available when needed for an activity. This is not to say that every conceivable piece of equipment should be furnished because the invention and construction of scientific and technological devices should be an important learning activity. Yet, the component parts need to be available.

In most cases, the sophistication of the equipment needed will increase as the sophistication of the learner activities increases and as the teacher's scientific competence increases. Because learners will grow unevenly in their scientific knowledge and skills, a wide variety of equipment will need to be available at many different grade levels.

One further concern needs to be mentioned. This model stresses the importance of out-of-the-classroom learning. It is equally important to have portable equipment that can be taken to field study sites. Weather instruments, soil and water testing kits, increment borers, Biltmore sticks, geology hammers, and much more are critically important for a quality science program.

All of these variables will need to be analyzed and a comprehensive science equipment plan will need to be written with attention to acquisition, storage, maintenance, and efficient availability.

Provided in this section are two documents that will be useful in the review, selection, and acquisition of instructional materials (print materials including textbooks, electronic media, instructional technologies, equipment, supplies, and expendables) for science education. The first, an excerpt from "Restructuring Science and Mathematics Instructional Resources", is a position paper assembled for use in instructional resource adoption. It was assembled by representatives from seven states (California, Michigan, Ohio, Oregon, Texas, Virginia, and West Virginia) for use in materials adoption in each of those states. Although Ohio does not have a state-mandated instructional resource adoption policy, Ohio participated in the project in an effort to benefit Ohio schools through this multi-state project. These same criteria will become part of the instructional resource (textbook adoption in some states) criteria and are designed as a guide for school use. These criteria are consistent with the spirit and intent of Ohio's Model Competency-Based Science Program. We would like to acknowledge the efforts of VQUEST, Virginia's Statewide Systemic Initiative, for their direction and assistance.

The second document in this section is a recommended minimum equipment list adapted from existing lists. Packaged science programs (such as NSF curriculum programs) provide similar lists. As a part of the school science program development process, schools should develop and have available on request a list of minimum science resources (equipment, supplies, and other materials) with acquisition and replacement schedules to be able to deliver the science curriculum. The list provided here is designed to be a guide, not as a mandatory equipment list.

Instructional Resources: Print and Nonprint

When coupled with interactive videodisc, CD-ROM, CD-I, as well as a myriad of new multimedia "learnerware," print and nonprint instructional resources will enable students and teachers to develop partnerships for learning as opposed to traditional textbook and teacher-driven models in the American classroom (Kerr, 1990). Students and teachers emerge from these integrated print-nonprint experiences having learned more about instructional design and learning principles. Even virtual reality and the new genre of imagery-based and experiential curriculum will find a place on the menu of options for alternative instructional resources, which share many essential features with textbooks (e.g., the application of instructional design principles) and should not be viewed as dissimilar. In "Alternative Technologies as Textbooks and the Social Imperatives of Education Change," Stephen Kerr (1990) expounds on the attributes of alternative instructional resources:

> ...students work at their own pace, in environments where progress and evaluation are nonthreatening; interest and motivation are piqued by novel methods of presentation (graphics, color, animation), and by elements of fantasy, challenge, and creativity inherent in the media themselves; achievement rises because the materials themselves give rapid, frequent, and exact feedback on a student's work; thinking skills and the ability to handle "higher order" cognitive tasks also improve. In their most developed form, materials become not mere collections of organized information, but true learning tools: they incorporate content, but also provide instructional helpmates that enable the learner to analyze and pose questions, retrieve information, organize it to solve problems and checkresults rapidly. They also allow the student to self-diagnose learning difficulties. As familiarity with the tool grows, the student progressively becomes the master of both tool and content.

Student assessment, integrated within the alternative instructional resources

- makes it possible for the instructional materials themselves (rather than the teacher) to assess students' work in an interactive mode;
- offers motivation and guidance as well as remedial support;
- allows students and teachers to work together in new ways;
- provides alternative ways of representing reality or of pacing progress through material, thus allowing individualized instruction according to the student's learning style; and
- allows students the opportunity (and consequently requires the skills) to work with problems that demand data in real-world quantities and varieties.

Criteria for the Selection of Mathematics and Science Instructional Materials

(Adapted from a working draft from VQUEST, 1994)

Criterion 1. Materials integrate a problem-solving approach.

Criterion 2. Materials emphasize connections within and among curriculum areas.

Criterion 3. Materials actively engage students in the use of processes.

Criterion 4. Materials provide opportunities that nurture scientific attitudes.

Criterion 5. Materials present opportunities to develop fundamental understandings of key scientific and mathematical concepts, principles, theories, and laws.

Criterion 6. Materials provide multiple means of assessment aligned with curriculum and instructional practices.

Criterion 7. Materials provide opportunities for interactive student participation in the learning process.

Criterion 8. Materials present content in a non-discriminatory manner.

Criterion 9. Materials are appropriate for the age, grade, and maturity level of students.

Criterion 10. Materials are presented in an organized, logical manner.

Criterion 11. Materials integrate learning technologies.

Criterion 12. Materials present content in an accurate and unbiased manner.

Criterion 13. Materials emphasize instructional practices that reflect current in mathematics and science education.

Recommended Types of Science Materials and Equipment

This listing is required by Section 3301.0720 of the Ohio Revised Code.

Safety Considerations

While the following section focuses on safety materials and equipment, it is essential to address a precursory concern by stressing that highest priority should be placed on prudent instructional practices, appropriate facilities, and a comprehensive risk reduction program.

Generally, safety equipment should be available to reduce risks to student and teacher health from injury or exposure to all hazards (e.g., biological, chemical, electrical, mechanical, radiation). This list represents an attempt to prioritize and categorically identify items for minimizing injury to students and teachers when accidents do occur. The materials and equipment suggested here in no way represent the optimum or essential; that will be influenced by no less than the instructional program locally supported and board approved. Moreover, the list contains items that are in no way to be considered a substitute for the precursory needs referenced above.

Safety and Emergency Equipment

Industrial quality eye protective devices (American National Standards Institute, Inc. (ANSI) Z87.1 standard) must be worn by all students and teachers at all times when working in science lab areas (Ohio Revised Code Section 3313.643).

Safety Glasses	Should be worn when students are at risk due to particle sprays (e.g., flying glass or other such projectiles). Side shields should be added.
Safety Goggles	Should be worn when students are at risk due to splashes or particle sprays (e.g., working with chemicals, hot liquids, or glassware under pressure)

Face and anchorable portable shields are not to be considered a substitute for safety glasses or goggles.

Face shields	Worn to protect the face and neck.
Portable shields	Used to provide full body protection.

A material of choice for and the use of the following items depends on the type of hazard associated with instructional activities, and appropriate standards and codes.

Lab coats	Worn to protect skin or clothing from splashes or particle sprays.
Gloves	Worn to protect students when skin contact hazards are present.

Ear plugs/muffs
Foot protection
Respirator Not to be considered a replacement for proper ventilation. Worn in emergency conditions.
Eyewash fountain
Safety Shower
Fume hood
Fire extinguisher
Fire blanket
Ground fault interrupt adapters
First aid supplies
Spill kits
Chemical storage cabinets and handling containers
Waste disposal containers for hazardous and infectious materials, and sharps
Safety and chemical hygiene library/resources

Recommended Types of Equipment for Elementary Science (K-4)

Animal Cage
Attribute blocks (set)
Balance, primer
Bulb holders
Dip nets
Graduated cylinders, plastic
Hot plate
Magnetic compass
Meter stick
Metric measuring cups (4 sizes)
Metric alcohol thermometer, standard and immersion
Prisms
Rock samples - variety, sizes and kind
Sea shells (assortment)
Steel mirrors (or polished non-breakable)
Incubator
Assortment of rubber stoppers with holes
Medicine cups, plastic graduated
Terrariums (plastic or glass)
Trundle Wheel
Assortment of nuts, bolts, washers, rivets
Bar magnet
Clock with second hand
Equal arm balance
Hand lenses
Light source (crook neck)
Medicine droppers
Metric measuring tape
Metric measuring spoons
Bow Caliper
Plastic water pitcher and bucket
Pulley
Safety glasses
Spring scale
Vials with lids
Weights/masses
Planter cups with bases
Plastic tubing (various sizes)
Aquariums (plastic or glass)
Multi-shaped Liter set
Rulers, primary relationship and all-purpose

Recommended Types of Living Materials

Elodea
Guppies
Fish food
Snails (land and water)
Brine shrimp
Sow bugs

Mealworms
Crickets
Seeds (i.e. beans, corn, radish, grass, clover, rice, squash, etc.)

Recommended Types of Consumables

Balloons
Plastic wrap
Masking tape
Colored pencils
Pipe cleaners
Fertilizer
Flashlight bulbs
Food coloring
Vinegar
Detergent
Diluted iodine solution
Oil
Corn starch
Wax paper
Aluminum foil
Straws Glycerin
Hydrogen Peroxide (2%)
Baking soda
String and fishing line
Modeling clay
Brass fasteners
Rubber bands
Cover slips
Batteries
Insulated copper wire
Salt
Plastic bags
Twist ties
Alcohol (70% isopropyl)
Clorox
Paper cups
Plastic spoons

A variety of science trade books and electronic media is strongly recommended for elementary science. Science textbooks are optional depending on program.

Recommended Types of Equipment for Middle Level Science (5-8)

- Ammeters and Voltmeters
- Aneroid barometer
- School Balances,
  - triple beam or double pan w/weight sets
- spring, 250g
- Balls, steel - 1 inch
- Beakers, pyrex - 100 ml
- Beakers, pyrex - 100 ml
- Beakers, pyrex - 250 ml
- Beakers, pyrex - 2000 ml
- Bottles - dropping
- Brushes
  - beaker
  - pipette, small
  - test tube, regular
  - test tube, small
- Charts
  - periodic table
  - metric SI measuring system
- Compass, magnetic
- Convection box
- Extension cords, heavy duty
- Flasks, Erlenmeyer - 2000 ml
- Flasks, Erlenmeyer - 250 ml
- Friction plates
- Funnels, short stem, plastic
- Graduated cylinders - 1000ml
- Graduated cylinders - 10 ml
- Hot plate
- Hygrometer
- Insect - nets
- Laboratory cart
- Magnets, bar, flat
- Medicine droppers
- Metric rulers, 30 cm
- Microscopes - stereo
- Mirror - concave
- Mirror - plane
- Model - cell
- Model - ear
- Model - heart
- Model - land form
- Model - mitosis/meiosis
- Model - world globe
- Overflow cans w/6 rectangular solid sets
- Petri dishes, glass, pyrex
- Prism, glass, equilateral
- Protractors
- Pulley, single sheave - 6 double & 6 triple
- Radiometer
- Anemometer
- Aquaria - 10 gallon
- Aquaria supplies
- Fish nets
- Filters (to fit aquaria)
- Pumps
- Heaters
- Light source
- Beakers, pyrex - 1000 ml
- Beakers, pyrex - 600 ml
- Bottles - wash (plastic)
- Bunsen burners w/ hoses and wingtip
- Cages, animal
- Carriages, Hall's
- Ceramic centered wire screens
- Clamps, Hoffman
- Clips, alligator with wire
- Cloud chamber
- Conductivity indicators
- Cork borer set and sharpener
- Flashlights, regular size
- Flasks, Erlenmeyer - 1000 ml
- Friction Block set
- Friction rods (hard rubber or glass)
- Geiger counter, w/speaker
- Graduated cylinders – 25-100 ml
- Hammer, rock
- Hydrometer
- Ice Crusher
- Insect - pins
- Light source w/ appropriate bulb
- Magnifying glasses (hand lens)
- Meter sticks
- Microscopes - regular, student
- Mineral set, labeled (teacher use)
- Mirror - convex
- Model - celestial globe
- Model - eye
- Model - flower
- Model - human torso
- Model - lung demonstration
- Model - planetarium
- Mortar and pestle
- Paper hole punch
- Plant mobile and timer
- Power supply, DC w/16 prs. of leads for student teams or batteries as
- Power source
- Rain gauge

Refrigerator
Rheostats, bulbs, motors, and resistors
Rock set, labeled (teacher set)
Rods, glass stirring - 12"
Slides, microscopes
Soil sampling tube
Spatulas, scoop
Spectrum tube power supply & holder
Spectrum tubes, gas - H
Spectrum tubes, gas - Ne
Stoppers, rubber (assorted)
Stream table and accessories
Switch, knife, electrical
Test tube holders
Test tubes - 15 x 125
Thermometers - Celsius
Thermometers - oral w/ disposable covers
Ring stands, w/ 4" rings
Rods, glass stirring - 6"
Spring Scales, bath, metric, clear plastic
Slinky or wave spring
Solar cell
Spectroscope or diffraction gradients
Spectrum tubes, gas - Ar
Spectrum tubes, gas - He
Stethoscopes
Stopwatch
Streak plates
Terrarium
Test tube racks, 8-hole
Test tubes - 20 x 150
Thermometers - metal, backed, alcohol, calibrated

A variety of print materials and computer simulation and data handling and connective software is desirable. Textbooks for the middle level are optional depending on program.

Recommended Types of Equipment for Secondary Science (9-12)

This list depends on the nature of the science education program. The equipment is therefore divided by type. A variety of computing, electronic, live, and print materials should be provided depending on program. Textbooks are optional depending on program.

Although there is going to be an inherent difference in the equipment list as one goes from school district to school district which is based on the instructional program, there is a list of materials and equipment that will probably be found in every secondary program. The following is an attempt to provide that generic list. It must be kept in mind that the list which will be developed by the teaching staff of each school or district will be based on the units of instruction that are being used and therefore will be supportive of the school's or district's instructional program.

Electrical Devices:
Battery chargers
Coils
Generators
Hot plates
Incubators
Meters
Motors
Power supply units
Rectifiers
Rheostats
Solar cells
Switches
Transformers

Glass and porcelain ware:
Battery jars
Beakers
Bottles
Burettes
Capillary tubes
Crucibles
Flasks
Funnels
Microscope slides and cover slips
Mortars and pestles
Petri dishes
Pipettes
Stoppers
Vials
Watch glasses

Kits:
Electrical circuit
Electronic
Embedding
Polarized light
Transistor

Measuring and recording devices:

- Balances, electronic
- Barometers
- Boyle's law apparatuses
- Calipers
- Counters and timers
- Calorimeters
- Eudiometers
- Hydrometers
- Manometers
- Meter sticks
- Meters and gauges
- Scalers
- Tachometers
- Thermometers (alcohol and mercury)

Models and display materials:

- Anatomical models
- Atomic models
- Biological models
- Collections (insect, rock, plant, etc.)
- Embedded biologicals
- Skeletal mounts
- Specimen mounts

Optical devices:

- Binoculars
- Lenses
- Light filters
- Magnifiers
- Microscopes
- Mirrors
- Prisms
- Telescopes

Other laboratory equipment:

- Aquaria
- Aspirators
- Autoclaves
- Cages
- Calculators
- Cathode ray tubes
- Clamps
- Cloud chambers
- Color apparatuses
- Computer/access to terminal
- Demonstration radio transmitters and receivers

Desiccators
Fire extinguishers (demonstration)
Function generators
Germinating beds
Growing frames
Gyroscopes
Heat sources
Horsepower apparatuses
Insect mounting boards
Laboratory tables
Laser and Holographic equipment
Linear expansion apparatuses
Liter blocks
Magnets
Microtomes
Nets (Aerial and Aquatic)
Optical benches
Oscilloscopes
Photoelectric cells
Photometers
Planetaria
Probeware
Protoboards
Pulleys
Pumps
Radiometers
Ripple tanks
Simple machine apparatuses
Spectroscopes
Steam generators
Sterilizers
Stoppers (rubber)
Stroboscopes
Terrariums
Tongs
Transector apparatuses
Tubing (rubber or plastic)
Tuning forks
Van de Graaff generators
Vivariums
Water baths

Instructional materials and equipment ought to be reflective of each classroom's, school's, and district's programs. Therefore the preceding generic list of materials and equipment should not be construed as being all encompassing or as one that will be reflective of specific school programs. Each secondary science program will necessitate the generation of an inherently unique set of equipment and instructional materials. The following is an example of what an equipment list might look like when the selection is based on the needs of one instructional unit.

Equipment and materials needed for working with DNA at the secondary level.

DNA unit - Equipment and materials list

- micropipettes or capillary tubes
- microfuge tubes (Eppendorf tubes)
- tips for micropipettes
- gel boxes
- gel forming trays
- power supply
- stains (methylene blue or ethidium bromide)
- viewing box (light box or transluminator (depending on stain)
- restriction and modifying enzymes
- bacterial strains for transformation or as sources of plasmid DNA
- freezer-refrigerator for storing enzymes and bacterial strains
- buffers for electrophoresis (e.g,. TBE or TAE) or reagents to make buffers that are required
- agarose
- centrifuge tubes
- culture tubes
- inoculating loops
- hotplate mixer or microwave
- bunsen burner
- sterilizing device (autoclave or pressure cooker)
- dry air oven or stove
- culture media for bacteria
- petri dishes
- flasks and beakers
- 10 ml. and 1 ml. glass pipettes

additional equipment based on the program

- microfuge
- centrifuge
- DNA sequencing equipment
- shaking waterbath
- incubator
- DNA purification reagents or kits

Safety equipment and materials

- a copy of the NABT (National Association of Biology Teachers) guidelines for working with recombinant DNA or the NIH (National Institutes of Health) guidelines for working with recombinant DNA
- gloves
- UV protective goggles
- pipette pumps
- soap
- containers for contaminated pipettes and tips
- autoclave or pressure cooker
- Material Safety Data Sheet for the reagents used in the lab

APPENDIX C

HEALTH AND SAFETY ISSUES IN THE SCHOOL SCIENCE EXPERIENCE

Safety as a Habit

Safety in school science programs is of critical concern to the Ohio learning community. At the heart of this concern is the trust placed in the hands of school leaders when learners enter school. It is the responsibility of school leaders to practice reasonable and ordinary care, and common sense in the planning and implementation of learning episodes. It is essential to cultivate good safety habits for both learners and leaders. It is worth emphasizing here that the development of good safety habits is embedded in the four instructional strands of this model and it behooves school leaders to address the development of these practices in locally developed science programs.

Resources, Facilities, and Practices

Suitable facilities are essential for carrying out a comprehensive school science program. Such a program is characterized by having all students, at all developmental levels, participating in a wide variety of engaging, hands-on, minds-on, inquiry-based learning episodes. (See An NSTA Position Statement – Laboratory Science). It is equally essential for learners and leaders engaged in these learning episodes to be aware of, to anticipate, and to plan for potential hazards of the worst-case scenario. The hazards discussed in this section are those associated with materials and procedures essential and integral to these learning episodes.

Schools with better science learning centers, and science leaders and learners well-versed in prudent practices associated with science learning episodes are capable of following better safety procedures and supply/waste management practices. Schools lacking these assets are more likely to be at risk in these matters.

In this context, the State Board of Education made the following recommendation to the Legislative Committee on Education Oversight (as found in *A Report From The State Board Of Education To The Legislative Committee On Education Oversight*, As Required By Amended House Bill 270, June 14, 1993): "The safety and health standards included in the Federal Occupational Safety and Health Act [as referenced in Substitute House Bill 308 will be applicable to all Ohio schools]. The State Board of Education recommends to the Legislative Committee on Education Oversight that appropriate provisions of House Bill 308 be extended to include students." To provide school district leaders insights into the elements of a program which address health and safety concerns inherent in effective school science programs, elements to be considered when developing a risk reduction plan will be presented. (See Occupational Safety and Health Administration Standards)

Health and Safety Addressed in Laws, Codes, and Standards

The following listing is illustrative of the web of health and safety laws, codes, and standards originating from various entities and agencies at the state and national level. The listing should not be considered comprehensive. It is prudent for and remains the responsibility of school district leaders to keep informed about the details of all such mandates; communicate pertinent information about all such mandates; and to obtain and allocate the resources necessary to attain compliance with all such mandates.

Laws

Asbestos Hazard Emergency Response Act (AHERA) - EPA

Toxic Substances Control Act - Environmental Protection Agency (EPA) - Indoor air quality

Title IV - Superfund Amendments and Reauthorization Act (SARA) - EPA - Indoor air quality

Resource Conservation and Recovery Act (RCRA) - EPA

Title III Emergency Planning and Community Right-to-Know Sections 301-304, 311-313 (EPA)

Code of Federal Regulations (CFR), Appendix C, Part 20, Title 10 - United States Nuclear Regulatory Commission (NRC) exempt quantities

Ohio Revised Code, Section 4121.37, 121.04, and 4167.01 to 4167.18 –Establishes the Division of Occupational Safety and Health and will have school districts obligated to be in compliance with standards no less stringent than those standards adopted by the national Occupational Safety and Health Administration (OSHA). While provisions of Sub. HB 308 have individual compliance time-lines, communication, compliance, and enforcement of all provisions will take place by January 1, 1995.

Ohio Revised Code 3301.0720 – Considerations for safety in school science programs

Codes (Mechanical, Building, and Administrative)

Ohio Fire Code 1301:7-7-29 Sections A - H address a broad range of concerns for laboratory safety such as electrical and ventilation requirements, safe egress, emergency response, right-to-know, and others.

Specifically, section 1301:7-7-16 FM-1705.1 states, "All operation and maintenance of all educational laboratories shall be in accordance with the requirements of National Fire Protection Association (NFPA) 45 standards listed in rule 1301:7-7-35 of the Administrative Code."

Ohio Revised Code (ORC) Section 3313.643 speaks to requirements for the use of industrial quality eye protective devices in school learning centers.

ORC Section 3707.26 calls for the Ohio Department of Health (ODH) to conduct semi-annual school inspections.

ORC Section 3707.03 calls for the ODH to abate nuisances or unsanitary conditions.

Ohio Administrative Code (OAC) Part 3701-71-02(C)(7) "Table of Exempt Quantities - Provides lists of materials regulated by the state of Ohio.

OAC 3701-38-14(A) - Exposure to Minors

Standards –Industry and Professional

Council of State Science Supervisors

National Science Teachers Association

American National Standards Institute

National Institute for Occupational Safety and Health

Underwriters Laboratory

Occupational Safety and Health Administration Standards

It is prudent and responsible for school district leaders to take steps to reduce risks inherent in learning episodes characteristic of a comprehensive and engaging science program. The Occupational Health and Safety Administration (OSHA) defines essential standards in Part 29 of the Code of Federal Regulations (OSHA 29 CFR) conducive to minimizing risk to the health and safety of leaders and learners participating in learning episodes in science learning centers.

A short list of sections from CFR 29 is provided as a quick reference to guide your research on this matter. As a starting point, Title 29 CFR includes requirements and guidelines on the following topics

1910.	General Workplace Standard
1910.Subpart Z	Exposure Standards
1910.133	Eyewear Standard
1910.134	Respirator Standard
1910.1028	Benzene Standard
1910.1030	Bloodborne Pathogens
1910.1048	Formaldehyde Standard
1910.1200	Hazardous Communication Standard
1910.1450	Occupational Exposure to Hazardous Chemicals in Laboratories
1910.20	Access to Employee Exposure and Medical Records

Prudent Practices

At such times when new evidence becomes available and conditions for operating school science programs change, the relative hazards associated with some materials and procedures require the assignment of a higher priority to considerations of such matters in a qualitative risk-benefit analysis program. However, few laboratory materials and procedures are without hazard. Therefore, as part of a pro-active approach, it is prudent to minimize risk to learners participating science learning episodes by adopting comprehensive precautions and procedures.

To begin a risk reduction program, school leaders should at least:

- Become informed about all issues surrounding a risk reduction program(e.g., applicable laws, codes, standards; essential elements of a enriching and comprehensive science education program; prudent practices)
- Assess qualitatively the risk levels associated with the school district's science program, science learning centers (inside and outside), learning episodes and level of competence of leaders and learners.
- Convene a risk reduction committee comprised of members from the schools district's community of leaders and learners
- Develop a local risk reduction and safety component for the school district's educational philosophy
- Utilize a competency-based, qualitative risk-benefit analysis approach to implement the school districts risk reduction plan

Supplies/Waste Management Practices

It is prudent and responsible behavior for school district leaders to adopt supply and waste management practices that illustrate concern for the health and safety of learners and the environment. Such practices should take into consideration **reduce and replace** practices that include at least the following elements:

- Microscale supplies and materials utilized in learning episodes to minimize exposure during use and amounts of waste produced.
- Substitute other materials for undisputed hazardous materials that pose undue risks from exposure during usual and ordinary use.
- Eliminate procedures when
    - the procedures involve practices or processes that fail a qualitative risk-benefit analysis;
    - substitutes for materials and supplies used in the procedures cannot be found; and
    - alternative procedures, simulations, and multimedia approaches do not provide instructional value commensurate with the original procedures.
- Keep only quantities of supplies and materials needed for the learning episode within the learning center.

Acquisition Practices and Policies

The practices school leaders follow to acquire supplies and materials for the school district's science program can have a direct impact on the amount of materials entering the waste stream, the safety and health of learners, and the environment. School leaders can minimize risk to learners and the environment, and optimize the effect of resources devoted to support effective, engaging and comprehensive science programs by considering at least the following elements:

- Quantify the school district current inventory of supplies and materials associated with the science program.
- Maintain accurate records of amounts of supplies and materials consumed during a year's operation of the school district science program.
- Project an anticipated inventory for the ensuing year relative to the difference between the current inventory and the amounts of supplies and materials consumed in the current year.
- Equalize imbalances between the amounts consumed and the current inventory across a school district's or purchasing consortia's pre K-12 science program whenever possible.
- Order anticipated inventory amounts of supplies and material for the ensuing year, and whenever possible
    - Use current inventory first;
    - Order amounts that can be consumed in a year's time;
    - Order live specimens annually; and
    - Optimize buying power by
        - coordinating school district orders of preK-12 supplies and materials across the entire science program;
        - forming purchasing consortia (e.g., through county offices of education); and
        - minimizing the cost of disposal for unused, expired supplies by purchasing only the amounts needed.

Please refer to the Occupational Safety and Health Administration Standards for expanded coverage of prudent practices. Additional information sources are listed in the Resources and Bibliography sections of this document.

APPENDIX D
SCIENCE EDUCATION RESOURCES

There exists in Ohio a large number of resources which are available to help teachers, parents and other educators deliver the highest quality science program possible. This section provides a brief listing of resources that are available for technical assistance. None of these lists are designed to be exhaustive, but rather are designed to provide a place to start. All of the resources listed can provide assistance for the school science program.

Ohio Department of Education

The most important mission of the Ohio Department of Education is to provide technical assistance to schools in designing and providing the best educational programs for the children of Ohio. Children are the future of Ohio.

The Division of Curriculum, Instruction and Professional Development (CIPD) is the primary division in the department charged with science curriculum and instruction. Other needs can be met by contacting the Ohio Department of Education using the Ohio Educational Directory.

CIPD, Curriculum, Instruction, and Professional Development Phone: (614) 466-2761

Competency-Based Education –Frank Schiraldi (Assistant Director)

Science Education – Rowena Hubler
Stan Santilli
Charles Warren

Environmental Education – John Hug

Technology Education – Dick Dieffenderfer

BATS – Buckeye Assessment Teams for Science
The BATS project is an ODE initiative designed to help school districts with local curriculum development including CBE assessments and intervention.

For more information, contact the Division of CIPD.

Ohio Department of Natural Resources

Education Section
Diane Cantrell (Deputy Chief, Division of Soil and Water Conservation)
1939 Fountain Square, Building E-2
Columbus, OH 43224

Science Education Organizations - National

NSTA – National Science Teachers Association
Bill G. Aldridge
Executive Director
11840 Wilson Blvd.
Arlington, VA 22201-3000

SSMA – School Science and Mathematics Association
Don Pratt
Bloomsburg University
Department of Curriculum & Foundation
Bloomsburg, PA 17815

NESTA – National Earth Science Teachers Association
Frank Ireton
Executive Advisor
American Geophysical Union
2000 Florida Ave., NW
Washington, DC 20009

NABT – National Association of Biology Teachers
Mary Louise Bellamy
Education Director
11250 Roger Bacon Dr., #19
Reston, VA 22090

ACS – American Chemical Society
Sylvia A. Ware
Division Director, Education
1155 16th Street, NW
Washington, DC 20036

NAS – National Academy of Sciences
Stephen Push, Director
Office of News and Public Information
2101 Constitution Ave., NW
Washington, DC 20418

AAAS – American Association for the Advancement of Science
1333 H Street, NW
Washington, DC 20005

NSSA – National Science Supervisors Association
Kenneth Russell Roy
National Director
Glastonbury Public Schools
330 Hubbard Street
Glastonbury, CT 06033

AAPT – American Association of Physics Teachers
Bernard V. Khoury
AAPT Executive Officer
One Physics Ellipse
College Park, MD 20740-3845

Science Education Organizations - State

SECO – Science Education Council of Ohio (NSTA)
Diana Hunn, Executive Director
University of Dayton
Dayton, OH 45469-0512

OCESS – Ohio Council for Elementary School Science
JoAnn Fair, Executive Secretary
P.O. Box 5506
Grove City, OH 43123-5506

OAS – Ohio Academy of Sciences (NAS)
Lynn Elfner, Executive Director
1500 W. Third Ave.
Columbus, OH 43212

OESTA – Ohio Earth Science Teachers Association
Carl Bohn
6422 Cleveland-Massachusetts Rd.
Clinton, OH 44216

EECO – Environmental Education Council of Ohio
Executive Director
397 W. Myrtle Ave.
Newark, OH 43055

State Education Resources – State

Project Discovery
Nancy Eberhart
Ohio Department of Education
Curriculum, Instruction, and Professional Development
65 S. Front Street
Columbus, OH 43215

NASA – NASA Lewis Research Center
Teacher Resource Center
Mailstop 8-1
21000 Brookpark Road
Cleveland, OH 44135

Project Atmosphere
Marianne J. Ceritelli
1860 Wythe Street
Worthington, OH 43235

CORE – Central Operation of Resources for Educators
NASA CORE
Lorain County JVS
15181 Route 58 South
Oberlin, OH 44074

Science Education Organizations - Ohio Regional Level

West

West Regional Professional Development Center
Nancy Houston
Montogomery County Board of Education
451 West Third St., Box 972
Dayton, OH 45422

West Region Project Discovery
Janice Chappell, West Region Coordinator
Public Education Fund
2100 Kettering Tower
Dayton, OH 45423

Challenger Center
Kiser Middle School Dayton Public Schools
300 College Park Dr.
Dayton, OH 45469

Northwest

Northwest Regional Professional Development Center
Jan Scherger
1000 North Main Street
Findlay, OH 45840

Northwest Regional Project Discovery
Larry Williams
Northwest Regional Coordinator
The University of Toledo
2801 W. Bankroft St.
Toledo, OH 43606

SciMaTEC – Science Mathematics and Technology Education Center
Charlene Czerniak
College of Education and Allied Professions
University of Toledo
1260 Southwest Academic Center
Toledo, OH 43606

Teaching Science With Toys
Richard Hansgen
280 W. College Ave.
Bluffton, OH 45817

Northeast

Northeast Regional Professional Development Center
Linda Freeman and Jean Wynne
GCEDC - 901 RT
Cleveland State University
Euclid at 24th Street
Cleveland, OH 44115

Northeast Regional Project Discovery
Ray Knight
Northeast Region Coordinator
Unified Technologies Center
2415 Woodland Avenue
Cleveland, OH 44115

C.R.A.B.S. – Cleveland Regional Association of Biologists
David McNamara
Shaker Heights High School
Shaker Heights, OH 44120

Cleveland Regional Council of Science Teachers
Harry Nash
John Carroll University, Physics Dept.
Cleveland, OH 44118

CREST: Cleveland Revitalizes Elementary Science Teaching
LaWanna White
Cleveland City Schools
1380 E. 6th St.
Cleveland, OH 44114

Lakeland Area Center for Science and Mathematics
James Porter
Lake County Office of Education
Painesville, OH 44077

EQUALS/Sequels, Family Math & Family Science Project
Marie French, Coordinator
R.T. 1319
Euclid at E. 24th
Cleveland, OH 44115

East

East Regional Professional Development Center
Joan Burrier
Stark County Board of Education
2100 38th Street, NW
Canton, OH 44709

East Regional Project Discovery
Tom Love
East Region Coordinator
The Education Enhancement Partnership, Inc.
220 Market Avenue South
Suite 350
Canton, OH 44702

Ohio Section/AAPT
Frank Griffith
Department of Physics
The University of Akron
302 E. Buchtel Ave.
Akron, OH 44325

Project Link
Loren Hoch
The University of Akron
Akron, OH 44325

Science-Language Arts Integrated Program
The University of Akron
Akron, OH 44325

Science Activities Using Household Materials, Workshops for K-8 Teachers
Matt Arthur
Ashland University
Ashland, OH 44805

Project Moonbase, Project Seabase, Operation Physics, Operation Chemistry
Doris Simonis
404/401 White Hall
Kent State University
Kent, OH 44242

Lake-to-River Science Day
Daryl Mincey
Department of Chemistry
Youngstown State University
410 Wick
Youngstown, OH 44555

Southeast

Southeast Regional Professional Development Center
Susan Payne
Ohio University
College of Education
133 McCracken Hall
Athens, OH 45701

Southeast Regional Project Discovery
Christine Knisely-Engle
Southeast Region Coordinator
5855 Hopewell Church
Lancaster, OH 43130

Ohio University Teacher Leader Project
Ralph Martin
Ohio University College of Education
246 McCracken Hall
Athens, OH 45701

Appalachian Distance Learning Project
Coleen Sexton
124H McCracken Hall
Ohio University
Athens, OH 45701

South

South Regional Professional Development Center
Sharon Yates
University of Rio Grande
Anniversary Hall
218 North College Avenue
Rio Grande, OH 45674

South Regional Project Discovery
David Todt
South Region Coordinator
Shawnee State University
940 Second Street
Portsmouth, OH 45662

SOS AAPT – Southern Ohio Section, American Association of Physics
Teachers
Michael G. Grote
Phillips Hall
Ohio Wesleyan University
Delaware, OH 43015

The Center for Science and Mathematics
Thomas Carnevale and David Todt
940 Second Street
Shawnee State University
Portsmouth, OH 45662

SCAN Science Network
Karen Newland
Hillsboro City Schools
410 East Main Street
Hillsboro, OH 45133

Southwest

Southwest Regional Professional Development Center
Mark Stevens
Coordinator
Hamilton Co. Office of Education
11083 Hamilton Ave.
Cincinnati, OH 45231

Southwest Regional Project Discovery
Ann Dinkheller
Southwest Region Coordinator
Department of Mathematics
Xavier University
3800 Victory Parkway
Cincinnati, OH 45207

Center for Chemical Education/Terrific Science & Math
Mickey Sarquis, Director
Miami University, Middletown
4200 E. University Blvd.
Middletown, OH 45042

Center For Excellence in Science and Mathematics
Ed Jones
Miami University
301 McGuffey Hall
Oxford, OH 45056

Central

Central Regional Professional Development Center
Heather Ness and Judythe Hummel
Franklin County
Educational Council
52 Starling Street
Columbus, OH 43215

Central Regional Project Discovery
Robert Lower
Central Region Coordinator
Franklin County Board of Education
1717 Alum Creek Drive, Room 109
Columbus, OH 43207

Unified Science Systems
Vic Showalter
231 Battele Hall
Capital University
Columbus, OH 43209

PLESE: Program for Leadership in Earth Systems Education
Vic Mayer
249 Arps Hall 1945 N. High Street
The Ohio State University
Columbus, OH 43210

BESS: Biological and Earth Systems Science
Dan Jax
Bexley City Schools
348 S. Cassingham Rd.
Bexley, OH 43209

Comprehension Via Computers
Robert Tierney
257 Arps 1945 N. High Street
The Ohio State University
Columbus, OH 43210

Everyday World as a Science Library
Karen Robinson, Project Director
Education Department
Otterbein College
Westerville, OH 43081

Science & Mathematics Network of Central Ohio
Pat Barron
445 King Ave.
Columbus, OH 43201

Colleges of Education

There are forty-nine colleges and universities in Ohio that provide programs for teacher certification. They are listed in the Ohio Educational Directory, available from the Ohio Department of Education. A copy of the Directory has been provided to each school building in Ohio.

Eisenhower Clearinghouse for Mathematics and Science Education

The mission of the Eisenhower Clearinghouse is to catalog and provide access to the science and mathematics programs funded by the federal government. This clearinghouse, located at The Ohio State University, will by 1998 be electronically linked to schools to provide on-line assistance for the planning of science experiences for students.

Eisenhower Clearinghouse for Mathematics and Science Education
Len Simutis, Director
The Ohio State University
1929 Kenny Rd.
Columbus, OH 43210

ERIC Clearinghouse for Science, Mathematics, and Environmental Education

The ERIC system is one of the world's largest databases of educational materials and research. It is available at libraries all around Ohio. The Clearinghouse for Science, Mathematics and Environmental Education is located at The Ohio State University.

ERIC Clearinghouse for Science, Mathematics, and Environmental Education
David L. Haury, Director
The Ohio State University
1929 Kenny Rd.
Columbus, OH 43210

Museums of Science and Technology in Ohio

COSI, Ohio's Center of Science and Industry
Stephanie A. Martin
Vice President for Education and Visitor Programs
280 East Broad Street
Columbus, OH 43215

Cincinnati Museum of Natural History
DeVere Burt
Executive Director
1301 Western Avenue
Cincinnati, OH 45203

Cleveland Children's Museum
Dianne L. Smith
Education Department Coordinator
10730 Euclid Avenue
Cleveland, OH 44106

Cleveland Health Education Museum
Carolyn M. Bears
Director of Youth Education
8911 Euclid Avenue
Cleveland, OH 44106

Cleveland Museum of Natural History
Jan McLean
1 Wade Oval
University Circle
Cleveland, OH 44106

Dayton Museum of Natural History
Thomas Hissong
Curator of Education
2629 Ridge Avenue
Dayton, OH 45414

Great Lakes Museum of Science, Environment and Technology
Richard F. Coyne
Executive Director
1100 Chester Avenue, Suite 350
Cleveland, OH 44115

National Invention Center/National Inventors Hall of Fame
Executive Director
80 West Bowery Street, Suite 201
Akron, OH 44308

Business and Industry Science Organizations - a number of professional societies and organizations operate throughout the state of Ohio. Contact your local Chamber of Commerce for lists of their organizations.

Print Resources - see bibliography

Health and Safety Resources

The following references are provided to assist school districts in the development of a Risk Reduction (Chemical Hygiene) Plan. The materials listed below are offered as non-mandatory guidance. References listed here do not imply specific endorsement of a book, opinion, technique, policy or a specific solution for a safety or health problem. Other references not listed here may better meet the needs of a specific laboratory.

Materials for the development of the Chemical Hygiene Plan:

American Chemical Society, 1155 16th Street, NW, Washington, D.C. 20036.
American Chemical Society, Safety in Academic Chemistry Laboratories, 5th edition, 1990.
American Chemical Society, Developing A Chemical Hygiene Plan.

National Academy Press, 2101 Constitution Ave., NW, Washington, D.C. 20418
National Research Council, Prudent Practices for Disposal of Chemicals from Laboratories, National Academy Press, Washington, DC, 1983.

National Research Council/National Academy of Science, Prudent Practices for Handling Hazardous Chemicals in Laboratories, National Academy Press, Washington, DC, 1981.

Hazardous Substances Information:

IARC Monographs on the Evaluation of the Carcinogenic Risk of chemicals to Man, World Health Organization Publications Center, 49 Sheridan Avenue, Albany, New York 12210 (latest editions).

NIOSH/OSHA Pocket Guide to Chemical Hazards. NIOSH Pub. No. 85-114, U.S. Government Printing Office, Washington, DC, 1985 (or latest edition).

Occupational Health Guidelines, NIOSH/OSHA. NIOSH Pub. No. 81-123 U.S. Government Printing Office, Washington, DC, 1981.

The Merck Index: An Encyclopedia of Chemicals and Drugs. Merck and Company Inc. Rahway, N.J., 1976 (or latest edition).

Information on Ventilation:

American National Standards Institute, Inc. American National Standards Fundamentals Governing the Design and Operation of Local Exhaust Systems ANSI Z 9.2-1979 American National Standards Institute, N.Y. 1979.

National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

National Fire Protection Association, Fire Protection for Laboratories Using Chemicals NFPA-45, 1982.

Safety Standard for Laboratories in Health Related Institutions, NFPA, 56c, 1980.

Fire Protection Guide on Hazardous Materials, 7th edition, 1978.

Scientific Apparatus Makers Association (SAMA), Standard for Laboratory Fume Hoods, SAMA LF7-1980, 1101 16th Street, NW., Washington, DC 20036.

Information on Availability of Reference Material:

American National Standards Institute (ANSI), 1430 Broadway, NewYork, NY 10018.

American Society For Testing and Materials, 1916 Race Street,Philadelphia, PA 19103.

Chemical Abstracts Services. 2540 Olentangy River R., P.O. Box 3012,Columbus, OH 43210.

Food and Drug Administration, 5600 Fishers Lane, Rockville, MD 20857.

National Clearinghouse for Alcohol and Drug Information, P.O. Box 2345, Rockville, MD 20852.

National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269.

National Safety Council, 444 N. Michigan Ave., Chicago, IL 60611.

The Laboratory Safety Workshop, A National Center for Training and Information, Curry College, Milton, MA, 02186.

Underwriters Laboratories, 333 Pfingsten Rd., Northbrook, IL 60062.

Other resources available from the National Science Teachers Association, 1742 Connecticut Ave., NW, Washington, DC 20009.

Safety in the Elementary Science Classroom (Flip Chart)
Safety in the Secondary Science Classroom (Flip Chart)
Pocket Guides to Chemical and Environmental Safety in Schools and Colleges – Volumes 1-5
Science Safety Software (Interactive) – Elementary and Secondary Levels

Eye Safety

Ohio Society to Prevent Blindness, 1500 W. Third Ave., Columbus, OH, 43212.

Protect Their Eyes: An Eye Safety Guide for the Classroom.
Columbus, OH: Ohio Society to Prevent Blindness, 1981.

Safety and Chemical Hygiene Resources

Prudent Practices for Handling Hazardous Chemicals in Laboratories, National Academy Press, 2101 Constitution Avenue, NW, Washington, DC 20418, 1981.

N.J. Berberich, et al., Manual of Safety and Health Hazards in the School Science Laboratory, U.S. Department of Health and Human Services, November 1980; available from the Council of State Science Supervisors, Rt. 2, Box 637, Lancaster, VA 22503.

K.M. Reese, Health and Safety Guidelines for Chemistry Teachers, American Chemical Society, December 1979.

Handbook of Laboratory Safety, N.V. Steere, Ed. 2d ed., CRC Press, Boca Raton, FL, 1971.

Flinn Chemical Catalog Reference Manual, Flinn Scientific, P.O. Box 219, Batavia, IL 60510, 1994.

Laboratory Safety and Health, J.A. Kaufman, Kaufman & Associates, 101 Oak St., Wellesley, MA 002181, 1992.

Kaufman, James A., Laboratory Safety Guidelines and Laboratory Health and Safety Audio-Course. Wellesley, MA, 1989.

Other Resources

Center for Environmental Research Information (CERI), US EPA, 26 W. Martin Luther King Dr., Cincinnati, OH 45268.

Jakel, Inc. 6400 Robin Dr., Des Moines, IA 50322.

SAFE Science Teaching: A Diskette for Elementary Educators, 1990.

The Total Science Safety System, 4th Edition, 1991.

National Institute for Occupational Safety and Health, 4676 Columbia Parkway, Cincinnati, OH 45226.

U.S. Environmental Protection Agency, Indoor Air Quality Information Clearinghouse, P.O. Box 37133, Washington, D.C. 20013.

APPENDIX E

SAMPLE LEARNING SKILLS INDEXES

Enumerations of learning skills may be found in many publications. The lists not only vary in length but may be subdivided into quite different categories. Even the headings vary: learning skills, lifelong learning skills, critical thinking skills, higher order thinking skills, fundamental performance roles, and probably many others. The continuing development of these skills in learners now has become a major educational emphasis. As a science education program is designed the incremental development of these learning skills will be its backbone. Goal one and strand three provide additional insights into this skill development process. The learning skills lists that follow are offered only as a starting point. Some may not even fit your definition of a learning skill. Each school district should synthesize a list that is comprehensive and appropriate.

Example #1

PROCESSES OF SCIENCE*

The scientific endeavor involves continually examining phenomena and assessing whether current explanations adequately encompass those phenomena. The conclusions that scientists draw never should assume a dogmatic character as science necessarily is tentative. Authorities do not determine or create scientific knowledge, but rather scientists describe what nature defines and originates.

Those engaged in the scientific endeavor use and rely on certain processes. The processes can be arranged in an hierarchy of increasing complexity— observing, classifying, measuring, interpreting data, inferring, communicating, controlling variables, developing models and theories, hypothesizing, and predicting—but the processes scientists use usually do not and need not "happen" in this order.

OBSERVING
Examining or monitoring the change of a system closely and intently through direct sense perception and noticing and recording aspects not usually apparent on casual scrutiny.

CLASSIFYING
Systematic grouping of objects or systems into categories based on shared characteristics established by observation.

MEASURING
Using instruments to determine quantitative aspects or properties of objects, systems, or phenomena under observation. This includes the monitoring of temporal changes of size, shape, position, and other properties or manifestations.

INTERPRETING DATA
Translating or elucidating in intelligible and familiar language the significance or meaning of data and observations.

INFERRING
Reasoning, deducing, or drawing conclusions from given facts or from evidence such as that provided by observation, classification or measurement.

COMMUNICATING

Conveying information, insight, explanation, results of observation or inference or measurement to others. This might include the use of verbal, pictorial, graphic, or symbolic modes of presentation, invoked separately or in combination as might prove most effective.

CONTROLLING VARIABLES

Holding all variables constant except one whose influence is being investigated in order to establish whether or not there exists an unambiguous cause and effect relationship.

DEVELOPING MODELS AND THEORIES

Created from evidence drawn from observation, classification or measurement, a model is a mental picture or representative physical system of a phenomenon (e.g., a current in an electric circuit) or real physical system (e.g., the solar system). The mental picture or representative system then is used to help rationalize the observed phenomenon or real system and to predict effects and changes other than those that entered into construction of the model. Creating a theory goes beyond the mental picture or representative model and attempts to include other generalizations like empirical laws. Theories often are expressed in mathematical terms and utilize models in their description (e.g., kinetic theory of an ideal gas—which could utilize a model of particles in a box).

HYPOTHESIZING

Attempts to state simultaneously all reasonable or logical explanations for a reliable set of observations—stated so that each explanation may be tested and, based upon the results of those tests, accepted or denied. Although math can prove by induction, science cannot. One can only prove that something is not true. Accumulated evidence also can be used to corroborate hypotheses, but science remains mainly tentative.

PREDICTING

Foretelling or forecasting outcomes to be expected when changes are imposed on (or are occurring in) a system. Such forecasts are made not as random guesses or vague prophecies, but involve, in scientific context, logical inferences and deductions based (1) on natural laws or principles or models or theories known to govern the behavior of the system under consideration or (2) on extensions of empirical data applicable to the system. (Such reasoning is usually described as "hypothetico-deductive.")

*National Science Teachers Association. *The Content Core: A Guide for Curriculum Designers, Vol. I*. Washington, D.C., 1992.

Example #2

LEARNING SKILLS*

The eight lifelong learning skills listed below have purposely been described first in this publication to emphasize their primary importance. Because the development of these skills in students is so critical, great care must be taken to plan carefully for their acquisition by students. These skills are too important and complex to be left to serendipitous development.

Many lists of lifelong learning skills have been published. This list is a compilation and condensation that will illustrate the wide range of skills involved.

• thinking skills	observing, classifying, predicting, inferring, hypothesizing, interpreting
• decision-making skills	recognizing the need for a decision, identifying alternative, analyzing positive and negative

alternatives, examining values, making decisions

. . . .

• problem-solving skills	identifying, defining, information gathering, organizing, generating alternatives, developing plans, implementing plans, evaluating outcomes
• communications skills	speaking, writing, listening, discussing
• psychomotor skills	manipulating equipment, eye-hand coordination, kinesthetic sense
• mathematical skills	computing with whole numbers, representing data, solving problems
• interpersonal relations skills	cooperating, consensus building, developing group discussion skills, improving leadership skills

*Ohio Department of Education. Energy and Resource Conservation. 1985, p. 7-9.

Example #3

LEARNING SKILLS INDEX*

Thinking Skills

1. Classify
2. Rank Order
3. Process Order
4. Make Careful Observations
5. Interpret Symbols On A Map And Find Locations
6. Interpret Illustrations
7. Webbing Concepts
8. Make Comparisons And Analogies
9. Make Inferences And Deductions Based On Reasoning

Problem Solving and Decision Making Skills

1. Research Using Sources of Information
2. Conduct A Survey
3. Collect and Organize Data
4. Identify or Hypothesize Cause and Effect
5. Analyze Consequences And Suggest Alternatives
6. Conduct Experiments To Test Hypotheses Or To Test Variables Using Test Samples
7. Propose Solutions To Scientific Problems
8. Propose Solutions To Problems Involving Behaviors

Psychomotor Skills

1. Manipulate Materials To Construct Projects
2. Manipulate Equipment And Materials For Experiments and Demonstrations

Communications Skills

1. Follow Oral Directions
2. Listening Carefully
3. Expository Writing
4. Creative Writing

5. Creative Drawing

Mathematical Skills

1. Compute Figures
2. Estimate Quantities
3. Graph Data

Reading Skills

1. Increasing Vocabulary And Using Dictionaries
2. Comprehension Of Reading Passages
3. Follow Written Directions

Interpersonal Relations Skills

1. Work Cooperatively With Others
2. Developing Group Discussion
3. Improving Leadership Skills

*Ohio Department of Natural Resources. *Super Saver Investigators.* 1988, p. B-7-9

GLOSSARY

actuarial table	–	a table that contains premium rates, dividends, risks, etc., according to probabilities based on statistical records used by insurance companies.
attribute	–	a characteristic; students are asked to group objects according to such attributes as color, size, shape, or other identifiable characteristics.
authentic (alternative) assessment	–	refers to assessment procedures that are compatible with instructional objectives; assessment that is curriculum embedded.
chaos theory	–	a multifaceted, multidimensional theory which accounts for behaviors in the living and physical domains related to complexity, scale, and patterns of change.
cognition	–	mental processes by which knowledge is required.
competency-based education	–	an Ohio Department of Education program designed to assure appropriate instruction, assessment and testing, and intervention for Ohio's students in grades K-12.
component	–	serving as a element of something larger; constituent.
computer simulation	–	a computer program that models a real situation, for example, a re-creation of a science experiment that would be expensive or difficult to perform live or a commercial program.
concrete materials	–	materials used to allow students hands-on experience with science; also called manipulative materials.
constructivism	–	the idea that students build up (construct) their own knowledge as they are engaged actively in the learning process; also, learning takes place within a social and cultural environment.
cooperative learning	–	a learning situation in which small groups of students, under teacher guidance, cooperate in achieving cognitive and social learning objectives.
coordinated curriculum	–	a curriculum that coordinates all the domains of science which leads students to an awareness of the interdependence of the sciences and their place in the larger body of human knowledge.
course of study	–	usually developed at the district level, this document is more detailed than the Model and presents the specific subject objectives and performance objectives for each grade level; referred to in this Model as local district curriculum

curriculum model – a document developed at the state level that suggests the best thinking about the knowledge, skills, and processes students should know, and be able to do in a particular discipline, and that provides a structure within which to organize the other important curricular components of the instructional system including the design of alternative forms of assessment and intervention.

cycle – a recurring series of events.

data – a compilation of information (numeric or otherwise) gathered on a particular topic through the use of procedures such as interviews, observations, surveys, questionnaires, and others.

database – a collection of data.

deductive reasoning – a method of arriving at a conclusion by adhering to the rules of logic and definitions, theorems, postulates, and axioms as evidence.

developmental levels – based on the Swiss psychologist Jean Piaget's theory of the development of the intellect; the idea that intellect develops in stages that proceed from the perception of concrete objects to the formal reasoning involved in the formation and interpretation of concepts.

developmentally appropriate – instruction and activities chosen to reflect the cognitive level of the student.

discrepant events – activities or demonstrations that are counter-intuitive to a student's understanding of certain concepts and lead a student to question his or her understanding of that topic.

domain – a realm of scientific knowledge accepted as a coherent unit (e.g., living systems, physical systems, and earth/space systems) and identified in the National Science Education Standards.

estimates – reasonably close approximations of desired results arrived at through various strategies such as front-end estimation, rounding, or successive approximations; estimation should be practiced when measuring so students will have a good idea about reasonableness of a measure and about proper units for the measure.

ethics – behavior dealing with the values relating to human conduct, with respect to the rightness and wrongness of certain actions and to the goodness and badness of the motives and ends of such actions.

evidence – information relevant to problem solving.

evidence-based decisions – decisions made by students after they have reviewed sufficient information on a topic or issue, both negative and positive.

fact – a thing that has actually happened or that is really true.

Fibonacci sequence	a sequence of numbers in which each new term is generated by adding the two previous terms; traditionally, the sequence begins 1,1,2,3,5,8,13,..., but the sequence may be initiated with any pair of integers.
fractal	irregular and fragmented self-similar shapes; e.g., fractal curves can wriggle so much that they fall into the gap between dimensions.
hypothesis	an explanation that accounts for a set of facts and that can be tested by further investigation.
incidence data	information collected from a student's own experiences; allows a student to draw conclusions, and/or relationships between different events.
inductive reasoning	reasoning in which a number of cases are investigated and then a conclusion is made for all similar cases; the process of induction is that one moves from specific to general cases; the process starts with a large amount of information and seeks commonalities.
inference	mental process of deriving explanations from observations or information.
inquiry (enquiry)	the act of seeking information through questioning and experimenting.
instructional objective	a statement of the result that is expected of the learner following appropriate learning activities.
integrated curriculum	addressing, in one learning episode, competencies in more than one curricular area; it does not rely on artificial categorization of science knowledge.
issue-oriented science	instruction and activities based on relevant local or global issues and leading to student suggestions for possible solutions and strategies for the resolution of issues; designated "real world" issues through which concepts are presented (e.g., waste management, frugality in consumption sustainability of the environment).
learning episode	units, lessons, or events conducted an interactive learning context.
learner outcomes	statements of what students should know and be able to do as they move through the school system; they include acquiring, processing, and extending scientific knowledge.
levels of organization	the relative position or rank of components that form an orderly, functional, structured whole.
Logo	a computer programming language that enables the user to easily manipulate geometric shapes, patterns, and motion.
macro	prefix used to denote the total or complex structure of something (large).
micro	prefix used to denote "the little world"; the smallest part of something.

model	a standard or example for imitation or comparison; to show the structure of something.
MSDS - (Material Safety Data Sheet)	fact sheets that supply information about potential hazards, protection guidelines, and first aid procedures that must be maintained for each hazardous material in every work area.
multiple intelligences	includes at least seven intelligences – musical, bodily-kinesthetic, logical-mathematical, linguistic, spatial, interpersonal, intrapersonal; these intelligences are manifested in individuals in different ways at different developmental levels.
nonstandard measures	any units of measure which are not part of the metric or English measurement systems; examples: paces, handspans, sticks, paper clips.
performance-based education	based on the idea that learners should be able to demonstrate their abilities and skills; matches what is taught with what is required to be successful at work and in life; acknowledges that students learn in different ways; recognizes that learning time varies with student need; provides for verification through multiple indicators; and involves the local learning community in setting expectations for students and assuring that all of its graduates meet them.
performance events	activities that are relatively short-lived; usually part of a performance task that allows students to apply their knowledge to solve a problem.
performance tasks	long-term activities that allow students to apply their prior knowledge and learn to solve problems at the same time; teachers are able to assess student progress during all facets of this activity; projects.
portfolios	container of collected evidence with a purpose; contains documentation of a range of student skill and knowledge with appropriate self-evaluation.
preconception	an opinion formed beforehand.
problem solving	the ability to approach a situation in which a goal is to be reached and to design one or more appropriate causes of action to reach that goal.
process approach	Hands-on, Minds-on Science
program, local science	the pre K–12 curriculum, instructional and assessment practices, and associated activities of a school district
propaganda	information or ideas methodically spread to win over people to a given doctrine.
performance objective	observable indicators of student learning.

Performance Objective Levels:

acquiring scientific knowledge – observing, collecting, and recording data and information from various sources

processing scientific knowledge – organizing, interpreting, manipulating, and reformulating observations and data

extending scientific knowledge – applying, formulating, transforming, and communicating ideas in a variety of contexts

risk-benefit analysis	– a process of assessing the risks and benefits of a proposed course of action to determine if the action should be taken.
scale drawings	– pictures or drawings of real-life objects rendered in smaller or larger than life-size dimensions, with relative sizes maintained.
science	– a way of knowing and adapting; systematic knowledge of the natural world.
science process skills	– those skills that allow students to observe, classify, measure, use time/space relationships, infer, predict, control variables, interpret data, formulate hypotheses, define operationally, and experiment.
sense-extending devices	– instruments and tools that help students extend the natural limitations of their senses.
significant digits	– a nonzero digit of a decimal numeral whose purpose is more than merely placing the decimal point; (e.g. to express the precision of a measurement to a given level of accuracy – 2.00 kg); example: in 3006, all the digits are significant; in .00498, the zeros are not significant.
simulation	– an imitation of a particular appearance, form, or process.
spreadsheet	– a computer software program that manipulates data arranged in a rectangular array of cells.
strand	– a method of organizing the components that make up instructional objects that flow from pre K to grade twelve in this Model.
systemic curricular reform	– districtwide educational improvement that uses both top-down and bottom-up reform measures to design a policy structure that guides school-level change.
taxonomy	– classification system
technological heritage	– refers to the cultural and historical familiarity and usage of devices and procedures for performing everyday tasks.
technology	– the application of knowledge to satisfy needs and wants and extend human capabilities.

technology education	–	a comprehensive, experience-based education program concerned with the evolution, utilization, and significance of technology to the economy and environment, and its impact on industry, including its organization, personnel, systems, techniques, resources, products, and social and cultural aspects; important are the hands-on investigative, design-and-build, technical problem solving teaching approaches, and the integration of mathematics, science, and language arts concepts used in the study of communication technology, physical technology (manufacturing, construction, energy/power, and transportation), and bio-related technology systems content.
thematic ideas	–	main ideas e.g., patterns, scale, constancy, systems, models, that are used to integrate the concepts, sub-concepts, and facts from selected all domains of science; such organizing structures can be used to plan an articulated pre K-12 program.
theory	–	a formulation of apparent relationships or underlying principles of certain observed phenomena which has been verified to some degree.
webbing concepts	–	a visual or mental method of showing relevant relationships among several ideas, facts, or entities; visual webs often contain images, connecting lines, and explanatory textual material.

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